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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 800 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Life Member shall be a member whose service to the Association entitles him to special recognition by the Association.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

Initiation Fees	
Members	$ 3.00
Juniors	1.00
Associates	10.00
Corporate Members	10.00

Annual Dues	
Members	$ 6.00
Juniors	3.00
Associates	20.00
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This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

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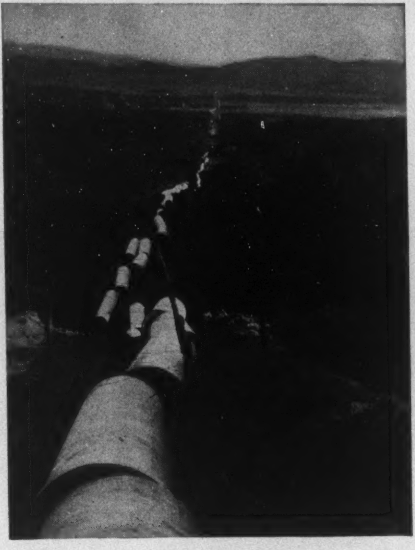

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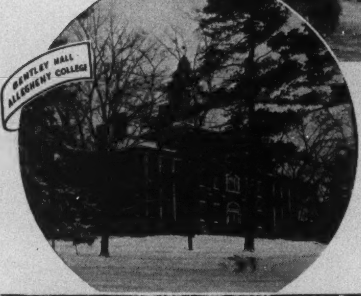

VIEW IN GROUNDS
OF WATER WORKS

Located in the extreme Northwestern corner of Pennsylvania, Meadville is a city having a population of 19,354, and is the center of a rich agricultural district. Here is the home of Allegheny College, a College of Liberal Arts of high standing, founded in 1815. This city has an interesting historical background; its Sesqui-Centennial was celebrated in May of this year.

Meadville is also an important industrial center, which includes the plant of the American Viscose Corporation, world's largest manufacturer of rayon, and the three plants of Talon, Incorporated, world's largest manufacturer of the widely used slide fastener.

The first public water system was built in 1874 by a private company and was purchased by the City of Meadville in 1899. The water supply is from wells located one mile from the city and is unusual in quality as no treatment of any kind is required. The wells are in glacial gravel, two of them producing over 2000 G. P. M. each.

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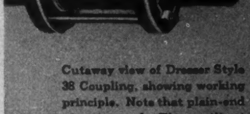

Cutaway view of Dresser Style 38 Coupling, showing working principle. Note that plain-end pipe is used. The resilient gaskets, flexing with the pipe, safely absorb pipe movements.

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This Association, as a body, is not responsible for the statements or opinions of any of its members

DOUBLE CHECK-VALVE MAINTENANCE AND TESTS IN CONNECTICUT

BY FREDERICK O. A. ALMQUIST*

[*Read September 15, 1938.*]

The list of water-borne disease outbreaks associated with cross-connections between piping systems carrying safe water and systems conveying unsafe auxiliary water used for fire-fighting or industrial purposes is impressive. The story is so well known to water works men that it seems hardly necessary to dwell on the grave public health danger inherent in improper cross-connections.

On September 13, 1927, W. J. Scott, Director of the Bureau of Sanitary Engineering of the Connecticut State Department of Health, presented before this Association a paper on "Cross-connections in Connecticut". Included were results of tests of double check-valves in Connecticut up to that time. The present paper will bring the results of double check-valve tests up to date and include a description of procedures for maintenance of check-valve installations together with other pertinent comments.

As a culmination of several years of recommending to local officials that steps be taken to prohibit cross-connections, the Public Health Council of the State Department of Health held public hearings in May and July, 1926, to discuss sanitary code regulations pertaining to cross-connections. On July 12, 1926, the regulations were adopted. The regulations read as follows:

Certain Cross-connections Between Water Supplies not Permitted

Reg. 118. After December 31, 1926, no physical connection between the distribution system of a public potable water supply and that of any other water supply shall be permitted, unless such other water supply is of safe sanitary quality and the interconnection of both supplies is approved by the State Department of Health.

No officer, board, corporation or other person or group of persons, owning or having the management or control of any potable water supply furnished to any municipality or water district, shall supply water to any person, firm or corporation who maintains such connection.

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*Associate Sanitary Engineer, Connecticut State Department of Health, Hartford, Conn.

Provided: That where such physical connections exist on December 31, 1926, and include two gate valves with indicator posts, two check valves of a design approved by the State Department of Health with drip cock and gauges for testing, all located in a vault of water-tight construction readily accessible for periodic inspection, the date of discontinuance may be temporarily extended, with the permission of the State Department of Health.

Permissible Arrangements Where Dual Supplies Are Used

Reg. 119. If a public potable water supply is used as an auxiliary supply delivered to a tank which tank is also supplied with water from a source with which cross connections are not permitted by Regulation 118, such tank shall be open to atmospheric pressure and the potable water supply shall be supplied above the maximum level of water in the tank. The tank overflow shall be of adequate size to fix definitely the maximum level.

If the auxiliary water supply is secured from a tank supplied only from a potable water supply and directly connected to a potable water supply, such tank shall be so constructed as to avoid any possible contamination of the water in the tank.

Non-potable Water to be Rendered Unavailable For Drinking

Reg. 120. No water supply shall be used or rendered available for drinking and for other personal or domestic purposes in any industrial plant, unless such supply is of safe, sanitary quality approved by the State Department of Health. If a water supply for industrial or fire protection purposes is obtained entirely or in part from a source not approved for drinking purposes, this supply shall be distributed through an independent piping system having no connection with the system for drinking and for other domestic use.

You will note that cross-connections with non-potable supplies were temporarily permitted with the approval of the State Department of Health, provided they existed on December 31, 1926, and double check-valves of the approved type with adequate facilities for testing were installed. The temporary permit is dependent on the results of periodic tests, and some idea can be obtained of the results of the tests in that most of the temporary permits are practically twelve years old. In a few cases of undiscovered old cross-connections, owners were allowed the option of installing double check-valves after the original date of prohibition.

For some time before and up to the time of the adoption of the regulations in question, water works officials, manufacturers and fire insurance companies had commenced work on elimination of cross-connections, and fortunately the work was well finished before the depression descended. Hartford and Stamford had already eliminated cross-connections, and surveys were made in other places throughout the state. Splendid coöperation was obtained from every one even though thousands of dollars were spent by some concerns. A number of manufacturers, contrary to recommendations of this department that cross-connections be eliminated, decided on installation of double check-valves, and in 1927 there were 162 installations in 100 factories.

The types of check valves approved by the Department were the so-called special Factory Mutual or F.M. valve and the bronze Rice or Underwood valve. The special F.M. valve is of iron body with bronze mounting and a flat rubber facing on the clapper. The Associated Factory Mutual Fire Insurance Companies have recommended the all-bronze type of valve. The all-bronze type contains a half-round rubber facing on the clapper causing a hair-line contact with the seat. Slotted bolt-holes allow the top of the check-valve to be easily taken off for cleaning and inspection. Since 1927 several new check-valve installations have been added and several discontinued. There are now 151 active installations of the following types:

Iron Body	
Grinnell	51
Ludlow	25
Chapman	19
Fairbanks	4
Pratt & Cady	4
Jenkins	2
Crane	1
Eastwood	1
	107
All Bronze[1]	44
Total	151

The cross-connection regulations require the double check-valve installation to consist of two gate valves with indicator posts, two check valves of the approved design, with drip cocks, and gages for testing, all located in a vault of water-tight construction readily accessible for periodic inspection. The gate valves, of course, are located one at either side of the double check-valves. Outside stem and yoke valves have been permitted, provided they were marked to show the direction of opening or closing. With this type of valve or with the indicator post type, one can readily determine whether the valve is open or closed. Indicator posts were not feasible at all locations. The check-valves should be spaced from three to five feet apart so that a long object in the pipe line cannot hold both valves open at the same time. The earlier installations were made with the two check valves close together. The added cost of a slightly longer pit or vault for the spacer is warranted by the increased safety. The length of the vaults usually recommended is from 9 ft. to 13 ft. depending on whether the installation consists of 6-, 8- or 10-in. valves.

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[1] All bronze in use are of two types, Grinnell and Eastwood Wire Corporation.

The procedure for testing follows closely the procedure suggested by the Associated Factory Mutual Fire Insurance Companies. The outside gate valve is first closed. It is necessary that no water be drawn from the system to lower the pressure or, if this is not feasible, a fire pump or other arrangement should provide a constant pressure against the check-valves. After the outside gate valve is closed, the drip cock between the gate valve and first check-valve is cracked open just enough to reduce the pressure. It is then closed. If the gate valve leaks, the pressure will increase to the former pressure. An outside gate valve that leaks too much will interfere with the test. The same drip cock is then opened wide, reducing the pressure between the gate valve and the first check to zero. If the pressure between the two check valves holds after dropping slightly and the drip practically stops, this indicates that the outside check-valve is tight. A leaking inside check-valve might cause the pressure to hold, but a slight drip would result to indicate a leaking outside check-valve. The next procedure is to crack open the drip cock valve between the two check-valves to cause a difference in pressure between the two sides of the inside check-valve, and then close the drip cock valve. If the pressure between the two check-valves does not increase, the inside check is tight. This can further be checked by opening the drip cock valve wide, after which the drip will soon cease if the inside valve is tight. Air should be expelled from the valves following the test.

We do not blow off test or drip cock valves before making the check-valve test. However, if there is a questionable test, we try it a second time. If the second test indicates no leakage, we credit the valves with being tight although the failure to operate properly on the first test is noted. With a very slight flow, sediment may be lodged on a check-valve seat which would not occur with any appreciable flow. If a valve is found to leak, the owner is required to open the valve for cleaning or overhauling while the inspector is there.

After testing, it is highly desirable to assure that the two main gate valves are left open and the pressure restored. We feel this is of such importance that after each installation is tested, our inspector obtains the signatures of the plant representative and water works representative on forms provided for the purpose and these are filed.

This calls for the three persons present to view the main gate valves and inspect the gages following the test.

A word of caution might be inserted at this point. Check-valve vaults may contain objectionable gases, especially illuminating gas from a leaky main. This gas may not always be noticeable as the odor may be absorbed in passing through earth, but it does not lose its danger. Persons have been overcome while making tests in vaults containing poisonous gases. The vaults in general should be entered with caution and a period of time should elapse after a manhole is removed before a person enters. An inspection should never be made alone. Wooden ladders should be watched as they decay easily in the damp atmosphere and may become unsafe.

Because of the great public health danger from improperly operating check-valves, it was decided that the Connecticut State Department of Health would do its own testing. When tests of double check-valves were first made by the department, they were made every second month. After several years, the frequency of testing was reduced to every three months, and for the past two or three years the tests have been made once every four months. Early it was found that a periodic cleaning of the valves would lessen the possibility of leaking valves, and an annual letter has been sent to each check-valve owner about the first of September asking that the check-valve covers be removed, that the check-valves be cleaned thoroughly and, if necessary, that the rubber facings be replaced with new ones. A form postal card is forwarded to be returned when the work is completed. A request is made that the card be returned by about November 10 and when the card fails to arrive, a follow-up letter is sent or, if necessary, a personal visit is made. A one hundred per cent return has been obtained.

The inspection department of the Associated Factory Mutual Fire Insurance Companies makes some pertinent comments on cleaning valves. Where more than one set of check-valves is found at a plant, only one set should be cleaned at a time. If there is only one service, pressure should be maintained on the sprinkler system with the fire pump or if by an elevated tank, it should be full and all valves open. Only one check valve should be cleaned at a time. The inside should be thoroughly cleaned, rust tubercles scraped off, the hinge pin removed and clapper cleaned, the test drain inspected, the gage connection examined and the rubber facing washed or replaced. The rubber facing should seat tightly and smoothly on a smooth seat and the clapper should be entirely free and capable of opening wide. If the seat is tight, a hollow sound will result when the clapper is

SUMMARY OF DOUBLE CHECK-VALVE INSTALLATION INSPECTIONS, JANUARY 1, 1927 TO JUNE 30, 1938 BY CONNECTICUT STATE DEPARTMENT OF HEALTH

Type of Valves	No. of Instal-lations	Period of Inspec-tions	No. of Inspec-tions	No. Instal-lations Leak-ing in Out-side Valve (City Side)	No. Instal-lations Leak-ing in In-side Valve (Mill Side)	No. Instal-lations Leaking in Both Valves	Both Valves O.K.	Test O.K. on Second Trial (Counted O.K.)	Per Cent Tests Leaking in One Valve	Per Cent Tests Leaking in Both Valves
Iron Body*	108	1/1/27	291	3	2	1	285	1		
All Bronze*	49	to	125	2	0	0	123	0		
Small Brass	2	6/30/27	6	0	0	0	6	0		
Total	159		422	5	2	1	414	1	1.67	0.24
Iron Body*	115	7/1/27	668	18	6	4**	640	4		
All Bronze*	49	to	291	1	0	0	290	0		
Small Brass	2	6/30/28	12	1	0	0	11	1		
Total	166		971	20	6	4**	941	5	2.68	0.41
Iron Body*	113	7/1/28	440	9	1	0	430	17		
All Bronze*	49	to	211	0	0	0	211	3		
Small Brass	5	6/30/29	19	8	0	1	10	1		
Total	167		670	17	1	1	651	21	2.69	0.15
Iron Body*	113	7/1/29	412	6	0	0	406	22		
All Bronze*	49	to	190	0	1	0	189	0		
Small Brass	3	6/30/30	12	0	0	0	12	0		
Total	165		614	6	1	0	607	22	1.14	0.0
Iron Body*	113	7/1/30	436	10	0	0	426	17		
All Bronze*	50	to	193	1	0	0	192	0		
Small Brass	3	6/30/31	13	2	0	0	11	1		
Total	166		642	13	0	0	629	18	2.03	0.0
Iron Body*	110	7/1/31	424	8	3	0	413	17		
All Bronze*	50	to	184	0	0	0	184	1		
Small Brass	3	6/30/32	10	0	0	0	10	0		
Total	163		618	8	3	0	607	18	1.78	0.0
Iron Body*	110	7/1/32	323	9	0	0	314	4		
All Bronze*	50	to	149	1	1	0	147	0		
Small Brass	3	6/30/33	9	0	0	0	9	1		
Total	163		481	10	1	0	470	5	2.28	0.0

SUMMARY OF DOUBLE CHECK-VALVE INSTALLATION INSPECTIONS, JANUARY 1, 1927 TO JUNE 30, 1938 BY CONNECTICUT STATE DEPARTMENT OF HEALTH (*continued*)

Type of Valves	No. of Installations	Period of Inspections	No. of Inspections	No. Installations Leaking in Outside Valve (City Side)	No. Installations Leaking in Inside Valve (Mill Side)	No. Installations Leaking in Both Valves	Both Valves O.K.	Test O.K. on Second Trial (Counted O.K.)	Per Cent Tests Leaking in One Valve	Per Cent Tests Leaking in Both Valves
Iron Body*	108	7/1/33	343	10	0	1	332	11		
All Bronze*	49	to	158	3	0	0	155	2		
Small Brass	3	6/1/34	8	1	1	0	6	0		
Total	160		509	14	1	1	493	13	2.95	0.20
Iron Body*	110	7/1/34	355	6	0	0	349	22		
All Bronze*	48	to	146	1	0	0	145	4		
Small Brass	3	6/30/35	7	1	0	0	6	2		
Total	161		508	8	0	0	500	28	1.57	0.0
Iron Body*	111	7/1/35	320	7	1	0	312	10		
All Bronze*	46	to	138	0	0	0	138	0		
Small Brass	2	6/30/36	6	1	0	0	5	0		
Total	159		464	8	1	0	455	10	1.94	0.0
Iron Body*	102	7/1/36	322	6	1	0	315	13		
All Bronze*	45	to	139	1	0	0	138	0		
Small Brass	2	6/30/37	6	0	0	0	6	0		
Total	149		467	7	1	0	459	13	1.71	0.0
Iron Body*	105	7/1/37	319	6	0	0	313	4		
All Bronze*	44	to	132	0	0	0	132	0		
Small Brass	2	6/30/38	6	0	0	0	6	0		
Total	151		457	6	0	0	451	4	1.31	0.0
Total†										
Iron Body*	110	1/1/27	4653	98	14	6	4535	142	2.41	0.13
All Bronze*	48	to	2056	10	2	0	2051	10	0.58	0.0
Small Brass	3	6/30/38	114	14	1	1	98	6	1.32	0.88
Total (All valves)	161‡		6823	122	17	7	6677	158		

*Approved Type.

**Installations have been corrected.

†Total for each class.

‡Average number.

lifted slightly and allowed to drop onto the seat. A new gasket is usually necessary under the valve cover. After cleaning, the gate valves should be reopened, pressure restored and all air allowed to escape at the gages, following which the check valves should be tested.

The results of the tests by the Connecticut State Department of Health are given in the accompanying table.

Of 6823 tests from January 1, 1927, to June 30, 1938, there were one hundred and twenty-two leaks in outside valves, 17 in inside valves, and 7 in both valves. Since 1929 only one installation was found leaking in both valves. This experience probably indicates improved maintenance.

The table shows somewhat better results for the all-bronze valves than for iron-body valves. This should be expected. Iron-body valves sometimes allow rust tubercles to grow near the clapper in such size that they actually interfere with the closing or seating of the clapper. Rust sediment may also interfere. In general the tests have shown remarkably good operating results for Connecticut double check-valves although single valves do, of course, leak occasionally and both valves may leak on rare occasions. It is felt that the good results are due to constant attention and periodic cleaning without which satisfactory results could hardly be obtained.

It is of interest that three sets of small brass check-valves were ordered removed because of continuous trouble in obtaining satisfactory tests. Small valves, although they appear to have the proper clearance, do not seem to operate properly. In the beginning, trouble was experienced with several valves manufactured by one concern, but after the valves had been visited by a factory representative and improved, good results were obtained.

Difficulty in testing may result from many causes such as a main outside gate valve leaking too much, a leaky drip cock valve, clogged connection to gage, air pocket, leak in check-valve to the outside, use of water in system so as to cause drop in pressure, low initial pressure and faulty gage. In most cases grit or sediment on the seat of the valve is responsible for a leak. This would indicate that the seat of the rubber facing is not always effective. There have been other causes of leaky valves. On opening one check-valve that did not test tight, a newspaper was found wrapped around the clapper. The newspaper had been wrapped around the clapper by the manufacturer to protect it in shipment and had inadvertently been left in place when the valve was installed. A crawfish was unkind enough to seek shelter under a clapper and to cause one check-valve to remain open on test. In one installation both valves were found to be leaking and when opened were found to be of the old type without rubber facings. Valves installed on a slant so as to hold the clappers open slightly at all times gave trouble, and two or three of these had to be changed to a horizontal position.

The experiences have not been without a trace of humor at some times. One of our men in lowering himself into a manhole and groping around with his feet for a place to stand, knocked off a gage. It is surprising how much water can issue from a small one-quarter inch connection in a short time. He spent the next several hours in the boiler room drying his clothes. In another instance a master mechanic while trying to loosen some concrete forms in the pit knocked a gage from the top of a valve. He tried to stay in the pit long enough to close the gate valve but was unable to do so. Fortunately a valve in the street was available. Such a valve is a safeguard and is desirable.

On the whole, it is felt that, thanks to the coöperation of the water works men, the fire insurance companies and the manufacturers, the cross-connection regulations and their operation,—both as to complete elimination of cross-connections and the check-valve situation,—have been successful and helpful in safeguarding public health. The efficiency can be gaged somewhat by the results of a survey now under way in Connecticut of interior piping conditions in buildings. As noted in a paper by L. K. Sherman of our department and presented before this Association last spring, an incomplete survey in the five largest cities in Connecticut so far reveals among many hundreds of establishments inspected, only five cross-connections with other supplies and only two of these were non-potable supplies. The detection of all cross-connections seems to be a never-ending job.

Conclusions

The tests on check-valve installations in the state of Connecticut over a period of twelve years have indicated that a great degree of reliance can be placed on these valves for safeguarding public water supplies. The statement should be qualified, however, by adding that the valves must be of the approved type, preferably of the all-bronze type, and properly maintained. Periodic inspections are unquestionably necessary if such valves are allowed. Required maintenance should include the opening of the check-valves for thorough cleaning and overhauling at least once a year. Complete separation of potable and non-potable supplies is, of course, preferable to protection by double check-valves. New cross-connections, even with check-valve protection, are not allowed in Connecticut and thousands of old cross-connections have been eliminated.

DISCUSSION

STEPHEN H. TAYLOR.[2] The following analysis of the performance of all installations of double check-valves on fire-supply services in New Bedford is based upon 5648 separate tests made over a period of 27 years.

The data cover 83 sets of double check-valves from 4 to 10 in. in size. These have been divided into three groups, i.e., active, inactive, and dead. The first group includes all check-valves at plants having an operative secondary supply or storage tank, (63 sets); the second group includes check-valves at plants having no secondary supply (16 sets); the third group includes three installations that were removed when the plants they served were demolished (4 sets).

Data for the five-year period 1933-1937, inclusive, have been separately analyzed for purposes of comparison with earlier results. Of 1694 inspections and tests made during the five-year period there was no case where both checks leaked, and *only one case* where one check leaked. This almost perfect performance record shows the value of the program of quarterly inspections and annual examinations which has been followed for the past five years.

The records show that rubber facings have an average life of about ten years, although there are several facings that have served for twenty-five years.

Fifteen sets of iron-body double check-valves with an aggregate life of 640 valve-years have been inspected 1015 times and never found leaking. The two all-bronze sets with an aggregate life of 28 years have been inspected 63 times and never found leaking.

HENRY E. HALPIN.[3] The records presented are very gratifying to me, extending, as they do, over a long period of years. Our own organization continues to be greatly interested and active in the inspection and maintenance of these valves. We have a special check-valve man, or two or three of our laboratory men who in the summer season, from about March to October, go around the country and do the internal inspection of the valves. At the present time we are checking about one-third of all of the double check-valves each year; that is, in a three-year cycle we will get over the whole number, which now amounts to about a thousand sets in the United States and Canada. The inspectors carry rubber facings with them. If they decide the facing needs renewal they can put it in then and there. We send the bill to the property owner for the facing at cost. We make it a plan to renew the clapper in all the iron-body valves;

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[2] Superintendent, New Bedford, Mass.

[3] Engineer, Factory Mutual Fire Insurance Companies, Boston, Mass.

special FM type every three years. We have come to the conclusion that the life of the round rubber facing on the all-bronze valve is about seven years. The older flat facing has a narrower seat ring and it tends to be indented. The round rubber facing has a wide seat and tends to give a longer life, although the compounds are the same.

There are so many leaking gate valves that interfere with the test that a request should be made to the property owner to repair these valves when necessary.

On the matter of new cross-connections, about three years ago we adopted the policy, falling in line with the best water works practice, that we would lay out no new cross-connections, and I am proud to say that in our department we have not laid out a single new cross-connection at any place. I think in the whole Factory Mutual system there may be one or possibly two that may have slipped in over our vigorous protest when the layout did not first come through our hands. In our own department we have had none at all.

On the matter of eliminating cross-connections, we have also got in line with the best practice. Last year Massachusetts passed new regulations. We have been working for many years to bring our plants into line with modern standards. But there were still some seventy Factory Mutual properties in Massachusetts that had old single check-valves, although we had made many attempts to get them out. With the passage of the new regulation, it provided the punch that was needed to either remove them or to replace them with double check-valves. The cross-connection was eliminated in about fifty per cent of the plants. Double check-valves have gone in at the remaining 50 per cent.

We recommend that the valves be tested for tightness by the property owner once a month. Some of the states have followed that practice. We recommend annual inspection. New York requires that in its regulations. The State of Maine requires that monthly tests be made by the water authority and the property owner. Massachusetts is now requiring a monthly test by the property owner, a test every three months by the water department, and an inspection by the State itself once a year.

CHARLES L. POOL.[4] We have got rid of many cross connections during the last five or six years, but I don't think we have put in more than six or eight sets of double checks.

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[4] Rhode Island Board of Health, Providence, R. I.

Francis H. Kingsbury.[5] We have recently started a program of requiring the manufacturer to inspect once a month and record the results in his log at the power house, and the water department to inspect four times a year, at one of which times the state inspector intends to be present. At that time the valve is opened. We have supplied forms to all towns in triplicate, and one of those forms for the quarterly inspection is retained at the plant, one retained at the water office, and one is sent to our office.

Arthur V. Harrington.[6] This work is rather new in our department, and after the regulations went into effect we made a very effective survey to determine the number of cross-connections and to sell the idea of eliminating them. We have records of contacts with approximately 1600 different concerns in Massachusetts, including some smaller types of concerns, like laundries and similar users of water. We have not been quite as successful as Connecticut was in that the concerns apparently want to maintain the cross-connections, and they have put in a number of double checks. At present we have a record of some 450 sets of double check-valves in Massachusetts. My estimate is that before we get through we will have in the vicinity of 700, which will have to be maintained and inspected annually. We have been in touch with the various water departments and asked that they communicate with the department and receive the forms, or request the forms necessary, but we have only received requests from approximately 60% of them. We are doing the best we can in trying to educate them in the process of testing double check-valves.

Alfred O. Doane. I have had rather a long experience in valves of all kinds, and this applies to gate valves as well as check-valves. One of the reasons why there is trouble with tuberculation at the seat is that, as a rule, when the seats are inserted the cast iron is machined off where the seat is inserted and that takes off a part of the cast iron that is most resistant to corrosion. Then the seat is put in, and the seat is bronze or brass, it is totally dissimilar from the cast iron, and that sets up a galvanic current, and the corrosion is simply intensified in the vicinity of the seat,—so much so that you will find in the old valves that the iron in the vicinity of the bronze seat is generally in such condition that it can be cut readily with a knife. This tuberculation, this spoiling of the seats, can be greatly minimized by raising the seat as much as is practical above the surface of the cast iron. That prevents to a great extent the tuberculation which is formed from growing over the seat, as it might very readily do if it was level.

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[5] Massachusetts State Department of Health, Boston, Mass.
[6] Massachusetts State Department of Health, Boston, Mass.

If the seat is a little loose, or if there is any chance for water to get in under the seat, the water will cause rusting, and, as everybody knows, rust exerts a tremendous pressure. It increases in size and will force the seat out of line under it, out of shape, and perhaps in some cases knock it out altogether. I don't know whether that trouble has ever been found in check valves, but we have had some very severe cases of it in large gate valves.

In reference to spraying metal onto the valve interior, that has been done in the case of some large cone valves, and I understand that after four or five years they are in good condition, but it is quite a costly process, and the cast iron, or whatever it is put on, has to be extremely clean. You can spray on any kind of metal which can be melted, but zinc is preferably used. You can put that on to any practical thickness that you want to pay for. The result is just the same as if you had a galvanized valve. But of course in all cases where zinc is employed as a protective agent, the zinc sacrifices itself to protect the iron and after a while the effect is gone.

In regard to the rubber seats. I have in the past had some trouble with rubber seats, probably when the composition was not just right. I have had a great deal of trouble with certain types of valves, with the rubber seat sticking to the seat, especially after it has been placed in close contact with pressure on it. Sometimes when the valve is opened a piece of rubber will come off and cling to the seat. I think that can be remedied by a compound. The way I remedied it was to have a compound made up with considerable graphite in it, which seemed to remedy the trouble.

JAMES J. DILLON.[7] While the program of cross-connection elimination has been curtailed to some extent during the last few years, the Providence Water Department deserves credit for its cross-connection elimination program. That department does not allow any cross-connections whatsoever, whether protected by check-valves or not, and it has gone ahead with its program of eliminating cross-connections wherever it finds them.

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[7] Rhode Island Board of Health, Providence, R. I.

WATERSHED SANITATION

BY DONALD C. CALDERWOOD*

[*Read September 16, 1938.*]

In 1852, when Nashua had a population of about 6000, a group of far-sighted citizens formed a company to secure and develop an adequate supply of water for what was then the towns of Nashua and Nashville. After much study given to investigation of the various watersheds in and about Nashua, the waters of Pennichuck Brook and its tributaries, with a drainage area of about 25 sq. miles, were selected as being of the best quality and of sufficient quantity to meet the requirements of a water supply system. The following year the company took the name of Pennichuck Water Works.

From 1854 to 1900 the water was taken, without treatment, directly from the brook, or ponds made by damming the brook, for the city's supply. In the late 1890's a supply was developed from springs and flowing wells which flowed by gravity into the so-called Supply Pond or pond nearest the pumping stations. To prevent the surface water from the valley mingling with that from the wells, a 72-in. penstock was built around this Supply Pond or storage basin in 1900. The water passing through the penstock is utilized to furnish power for pumping, the surplus being wasted into the brook below the Supply Pond. Since 1900 the surface or valley water has been held in reserve, and no use of it has been made, except for power, since 1910.

Our watershed sanitation therefore falls into two classes or areas: (1) A watershed area of about 24.71 sq. miles above the Harris Dam, or where the surface water enters the 72-in. penstock; and (2) a watershed area of about 0.65 sq. miles adjacent to our Supply Pond or ground water storage basin.

The large area of nearly 25 sq. miles, is largely wooded with only a moderate amount of agricultural development. For the most part, the buildings are widely scattered and are located at some distance from the various ponds and streams. The total population on the watershed is roughly estimated at 500 or about 20 persons to the square mile. The purchase of two dams, or mill sites, prevented or terminated industrial development along the stream, with its accompanying pollution problems.

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*Engineer, Pennichuck Water Company, Nashua, N. H.

Upstream from the inlet to the 72-in. penstock is a series of three ponds or storage reservoirs with a dam at the foot of each. These dams are constructed so that the height of water in each pond can be controlled. Under normal conditions there is a long retention period, as the total storage capacity is nearly 650 m.g. The company has holdings of about 700 acres adjacent to these ponds and owns the entire shore line for a distance of 12,000 ft. upstream from the inlet to the 72-in. penstock. Beyond this point little attempt is made at any control other than our actual land holdings which, in addition to the two dam sites and the 700 acres previously mentioned, consist of about 600 acres.

Actual control of our holdings consists of posting the land, forbidding trespassing, hunting, fishing, boating, and swimming. In the spring, when the ground dries out and before the vegetation turns green, one of the employees patrols the area looking for fires. It so happens that this period as a rule coincides with the beginning of the fishing season so the patrolman is on the lookout for fishermen, who, when found, are politely ordered off the premises. Other than during this period, no regular patrol is attempted, but all dams are visited daily and every few days some employee drives around our holdings to inspect the general conditions and note any changes. The foregoing applies only to the auxiliary surface supply which has not been used except for power during the last 28 years.

The smaller area of 0.65 square miles that forms the watershed of the Supply Pond is more carefully patrolled. It is closer to the city and adjacent to the pumping stations so naturally it is easier to keep track of conditions. The Water Works own over 150 acres or about 37% of this watershed, and their holdings are enclosed with barbed-wire fences, for the most part heavily wooded, and adjacent to the Supply Pond. The nearest house or building not owned by the company is over 2000 ft. from the shore of the Pond. With one exception, the nearest land not owned by the company is 1500 ft. away.

A map drawn to the scale of 80 ft. to the inch shows the area upon which there is any habitation, and on it is plotted the location of all buildings along with the number of inhabitants in each house, kind and amount of livestock, water supply, and type of sewage disposal. An annual survey keeps this information up to date.

There are thirty houses on the watershed area. Some are connected to the city sewerage system, others have septic tanks or are making other satisfactory disposal of sewage.

There is one very small stream, called Danforth Brook, that flows towards the area where the springs and flowing wells are located, but normally this disappears into the ground about 2000 ft. from the springs. Sometimes, during the spring thaws, when the run-off is excessive, instead of seeping into the ground, a portion of the run-off will flow much nearer to the springs and as far as an abandoned road that crosses the little valley in such a way that it forms a dike. Under extreme conditions, small quantities of water will flow over this dike and eventually find their way down to the springs and then run into the Supply Pond. This condition is very extreme and never lasts more than a few hours. During the spring thaws, this point is watched, and as soon as water starts to run over the dike, liberal quantities of HTH are added above the dike in an attempt to sterilize the water before it reaches the area adjacent to the springs. At the same time the chlorine dosage at the pumping station is increased and frequent ortho-tolidine tests are made to insure a satisfactory residual chlorine content at all times.

No regular patrol is maintained, other than that mentioned for the larger tract, but inspections are frequent. In making these inspections we find that best results are obtained by traveling on foot because in addition to closer inspection the likelihood of discovering trespassers is much greater than when using some means of conveyance. The person making the inspection usually carries a one-pound can of chlorinated lime, and if animal or human excreta are found liberal quantities of the lime are applied to them.

The State of New Hampshire has an unusually active Board of Health. It has fostered legislation and been instrumental in having legislation passed that gives them very broad powers where a public water supply is involved. Just recently they have ordered a town to install a sewage treatment plant to prevent sewage from entering one of the State's larger lakes.

From the foregoing it is easy to see that our watershed sanitation problems are few, thanks first to the farsightedness of those who acquired the large protective holdings of land, secondly to an excellent and coöperative State Board of Health, and lastly through years of education of the public to the fact that they have one of the finest water supplies and that it is up to them to help keep it so.

DISCUSSION

WARREN J. SCOTT.* I would like to ask if when you find an unsanitary condition on the watershed you have trouble in getting the watershed resident to correct the condition.

MR. CALDERWOOD. Both the state and local boards of health have authority to order people to do what they say is for the best interests of all. Our holdings are in two or three towns other than Nashua, and originally the local board of health only had power within the limits of the township. But at a session of the Legislature a few years ago that law was amended to give them the power to recommend and order changes at any place in the watershed, whether it is in Nashua or outside of the limits of the city of Nashua.

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*Connecticut Department of Health, Hartford, Conn.

MR. SCOTT. In Connecticut we have a similar situation where the local health officer of a town, or the policeman who may be appointed under a special act on the watershed, or the State Department of Health, after hearing, may issue orders. We also have a state law that we have called into play once or twice lately, which is very effective, giving the water company or water department, or local county health officer, the right to ask for an injunction against any watershed resident. That seems to be the most effective way of cleaning up where one has trouble with somebody who is trying to sell his property to the water company or the water department. The judge can then issue a definite order through an injunction, and this procedure cleans up the situation very quickly. There is also provision in the law whereby the resident may ask for compensation if he is put to any extraordinary expense.

MR. CALDERWOOD. In our particular case we have had very few problems of that nature,—in fact, practically none. Where we have asked the people to do certain things to clean up the watershed, they have been very coöperative and glad to do as we suggested. I think that our lack of troubles depends mostly upon the fact that we own such a large portion of the watershed, and also own so far back from the pond and actual water courses.

MR. SCOTT. One thing that impressed me is the fact that your men carry cans of chlorine disinfectant with them. It seems to me that this not only has some value from the standpoint of disinfection, but the fact that a disinfectant may be applied when the inspector goes through immediately impresses upon the resident of the property the fact of the danger. I would say that this practice had a good deal of educational value as well as offering some protection.

INDUSTRIAL USES OF WATER†

BY W. D. COLLINS*

[*Read September 16, 1938.*]

The entrance to a local business establishment in Washington, D. C., is flanked by two large posters like those at a theater entrance. One poster has in the center a picture of a steaming cup of coffee. Above is the name of the company and below is the statement: "Blended for Washington water." The poster at the other side of the entrance shows a pot of tea with the company name above and the same statement, "Blended for Washington water," below. The same statement is carried in newspaper and other advertising. Although this slogan has only recently been put into use, it was under consideration nearly two years ago. At that time a representative of the advertising agency obtained from the Geological Survey of the United States Department of the Interior some information about the chemical character of water supplies used throughout the United States. This was logical enough because for many years the Geological Survey has been making and publishing analyses of the mineral content of waters with reference to their industrial and agricultural use without any reference to sanitary problems. In connection with the distribution of the analyses a certain amount of information as to industrial and agricultural requirements is picked up, although the Survey makes no studies of such problems.

The Geological Survey has no first-hand knowledge of the relations between the composition of water and the proper selection of coffee or tea. A well-known book[1] about coffee has only one statement on this topic, which reads: "Very hard or very alkaline waters exert an unfavorable influence on the character of beverage coffee. Ordinary soft waters or waters of low hardness may be used without notable difference in the quality of the beverage."

In a book on tea[2] the same author discusses in some detail the relation of water quality to testing and to blending. He notes that blenders and buyers may ship to their testing laboratories samples of the water with which a tea is to be used in order to test the product to be sold in any area with the water that will be used by the consumer. In the book some six varieties are listed as being most favored for use with soft water, eight used for medium water, and nine that are best suited for use with hard water. It appears from all accounts, then, that for a dealer to sell the same kind of a cup of tea to a consumer in Boston and one in Jacksonville, Fla., he must be sure not to sell the consumer the same blend of leaves of tea. He must be more sure not to mix the shipments. I do not know whether the company trying to blend for Washington water follows the changes in composition of the water throughout the year. According to the most easily available collection of information on the subject[3] there is a considerable range in composition. It would be easier to maintain uniform adjustment to the quality of water from a very large reservoir or from an underground source. At that, the tea or coffee for Washington might well come in between the blends best suited for Boston or Jacksonville, as is indicated by the typical analytical results given in Table 1.

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†Published by permission of the Director, Geological Survey, United States Department of the Interior.

*Chief, Division of Quality of Water, Geological Survey, United States Department of the Interior, Washington, D. C.

[1] Ukers, William H., All about coffee: Tea and Coffee Trade Journal Co., 79 Wall St., New York, 2d rev. ed., 1935.

[2] Ukers, William H., All about tea: Tea and Coffee Trade Journal Co., 79 Wall St., New York, 1935.

TABLE 1—TYPICAL ANALYTICAL RESULTS FOR CERTAIN PUBLIC WATER SUPPLIES[4]
(Parts per million)

	TOTAL HARDNESS AS $CaCO_3$	TOTAL DISSOLVED SOLIDS
Boston, Mass.	15	43
District of Columbia		
Minimum	54	110
Maximum	128	175
Jacksonville, Fla.	270	390

The subject of adjustment of tea and coffee blends to water quality is only one of a number of subjects that bring to the Geological Survey requests for information as to the composition of water supplies. The requests may come from manufacturing, sales, or advertising departments, and frequently come from several different departments or branch offices of a single company.

The most widespread interest in the composition of water supplies seems to be among the distributors of soap and other cleansing agents. Their interest is mainly in the hardness only. Other commodities whose performance may be affected by the character of water with which they are used or items for which the demand is closely connected with the composition of water are generally known to include steam boilers and boiler-plant equipment, supplies and equipment for the treatment of water for industrial or domestic use, pipe of iron, brass, or copper, and laundry supplies and equipment.

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[3] Collins, W. D., Lamar, W. L., and Lohr, E. W., The industrial utility of public water supplies in the United States, 1932: U. S. Geol. Survey Water-Supply Paper 658, 1934.

[4] Collins, W. D., Lamar, W. L., and Lohr, E. W., The industrial utility of public water supplies in the United States, 1932: U. S. Geol. Survey Water-Supply Paper 658, 1934.

In the Geological Survey the term "industrial use" is taken to apply to any nonagricultural use that is affected by the chemical character of the water, except drinking, whether the use is in an industrial establishment or in the home. In a very large proportion of the difficulties encountered in the industrial use of water, whether in the home or in a manufacturing plant, the chief cause of trouble may be indicated as hardness, alkalinity, or corrosiveness.

Hardness. Hardness is the characteristic about which most inquiries are received by the Geological Survey. The hardness map from Water-Supply Paper 658 (reproduced herewith) has been included in a number of books and journal articles and has been used sometimes without proper consideration of the discussion of its limitations, which appears in the report.

Nearly everyone is acquainted with the troubles caused by hard water. The most common trouble results from the reaction between soap and the constituents that cause hardness, with the consequent deposit of insoluble soap on the bathtub and on articles washed in the hard water, both in the home and in the mill. In both places there are further troubles in laundering and dyeing. The next most common trouble is probably the formation of deposits or scale when the hard water is heated. Occasional boiler failures in the home and in industrial plants have resulted from scale deposits. In general, it is felt that a soft water is much superior to a hard water for industrial use. There are, however, some uses for which a hard water is distinctly superior. It has been suggested[5] that a total hardness of 200 to 300 parts per million is advantageous for brewing. The addition of calcium sulphate to increase the hardness is common practice. In bread-making it has been found profitable to add nearly 2,000 parts per million of calcium sulphate to the water. This makes the hardness about ten times the hardness of waters that are commonly considered to be hard enough to justify softening for general municipal or industrial supplies. In this connection, mention may be made of the use of calcium sulphate to correct very soft waters that, without such correction, would ruin any land on which they might be used for irrigation, because of their content of sodium bicarbonate. This is a factor that has been considered in relation to proposals to soften for municipal use water which in its natural condition is excellent for irrigation, but which, after softening, might be wholly unfit for irrigation.

Alkalinity. The alkalinity of a water may have a decided influence on its usefulness. Sometimes the controlling factor is the total alkalinity as determined by titration; at other times the controlling factor is the intensity of alkalinity or acidity as given by the hydrogen ion concentration, measured colorimetrically or electrometrically and reported in pH units. Excessive alkalinity may be objectionable in brewing.[6] During the era of extensive home brewing, complaints were received by some water companies which regularly gave a finishing treatment to the water to maintain a pH of 9.0 or more to prevent corrosion of mains and service lines. The householders making the complaints were having trouble with their brewing which is generally considered to proceed best at a pH below 7.0.

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[5] Lammers, F. J., Water purification in the modern brewery and distillery: Ind. and Eng. Chemistry, **26**, 1133-1138 (1934).

It has been reported[7] that in the manufacture of hard candy it is desirable to have the pH up to about 7.5 in order to prevent inversion of the sucrose which would make the candy sticky when exposed to moist air. For the manufacture of fondant, a low pH is desirable to favor inversion and make the resulting product smooth. The necessary adjustment of pH can be made so that water from the same supply can be used for both kinds of candy. Without treatment, however, a supply may be much better for one kind of candy than for the other. The alkalinity of the water used in the preparation of carbonated beverages has been reported[8] to have a striking effect on keeping quality. In one series of experiments using identical quantities of ingredients with different types of water, it was found that samples made with water of about the alkalinity commonly found in ground water in the Mississippi Valley had at the end of ten days 45,000 times as many bacteria as were found in the sample made with distilled water. This is, of course, a condition that can be corrected, and it must be.

An institution conducting a school for enbalmers requested information as to the chemical character of public water supplies throughout the country, especially as to alkalinity. It appears that the preservative power of formaldehyde solutions has been found to vary with the alkalinity of the water used unless allowance is made by varying the concentration or by modifying the alkalinity.

Corrosiveness. Corrosive water is likely to be a source of trouble everywhere. Its effects on mains and service lines have long been recognized in New England, and different means have been adopted to avoid them. There are differences of opinion as to the extent to which it is practicable and profitable to treat water so that it will not be corrosive. At filtration plants where coagulation is employed, it is becoming more and more the regular practice to make provision for final treatment of the water to prevent corrosion. This is usually done by the addition of lime. Cox[9] has given an account of the use of beds of crushed marble to prevent corrosion by supplies of small or moderate size and gives references to accounts of larger-scale plants in Germany. The directions given by Cox were found effective in treating a small supply in Virginia. The water contained almost no dissolved mineral water, some organic matter, and a comparatively large amount of free carbon dioxide. In passing through a copper line from the spring to the house, the water dissolved enough copper to become so unpalatable that all the drinking water for the house was brought from the spring by bucket or jug. Any textiles washed in the water with the use of soap took on a greenish-blue or bluish-green tint. After the treatment was begun the water was wholly satisfactory for drinking and no longer tinted the wash-cloths in the bathroom and the towels in the laundry.

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[6] Lammers, F. J., Water purification in the modern brewery and distillery: Ind. and Eng. Chemistry, **26**, 1133-1138 (1934).

[7] Jordan, Stroud, Minerals in water cause variations in product quality: Food Industries, **4**, 89-91 (1932).

[8] Buttler, Howland, Alkalinity control of ingredient water: Food Industries, **8**, 233-234 (1936).

Hardness Map. Some inquirers, especially those who are interested in learning, in a general way, the character of the waters used over large areas find the accompanying hardness map to give all the information that is desired. Others, who need to know about the water at some particular place or places with reference to the location of an industrial plant, are likely to find the map of no value, or less than no value. The map may be misleading. It shows only ranges of *weighted* average hardness for the states. The shading for some states might be changed by the omission of one city or the inclusion of one more. For detailed information about hardness it is necessary to consult the table of individual analyses. Even this is not adequate for some cities that are served from sources that vary in composition throughout the year; nor for other cities that have several sources of widely different characteristics. In some of these places certain parts of the cities receive water entirely from a single source; other parts may be served from one or another of two or more sources, according to changing demands in different parts of the city. These possible variations may cause considerable difficulty in the use or treatment of the water that would not be encountered with water of uniform composition.

It is well known that surface waters may vary in composition from time to time, usually inversely, but not proportionally with the discharge. In a series of analyses of 10-day composites of daily samples from the Ogeechee River at Eden, Ga. during the year ending April 30, 1938, the range in dissolved mineral content was from 35

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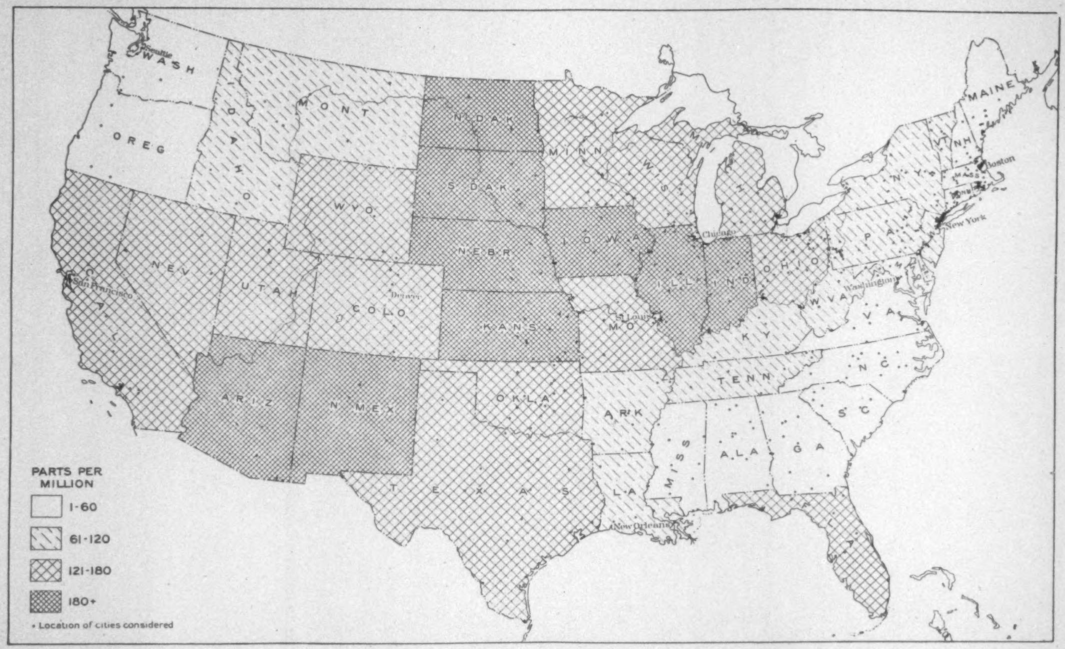
[9] Cox, C. R., The removal of aggressive carbon dioxide by contact beds of limestone or marble: Am. Water Works Assoc. Jour., **25**, 953-958 (1933).


PARTS PER MILLION
1-60
61-120
121-180
180+
• Location of cities considered
WASH
OREG
CAL
IDAHO
MONT
WYO
NEV
UTAH
COLO
ARIZ
N. MEX
N. DAK
S. DAK
NEBR
KANS
OKLA
TEXAS
MINN
IOWA
MO
ARK
LA
WIS
MICH
ILL
IND
OHIO
KY
TENN
MISS
ALA
GA
FLA
S C
N C
VA
W VA
PA
N Y
VT
NH
MAINE
MASS
CONN
Seattle
San Francisco
Denver
St Louis
Chicago
New Orleans
Washington
New York
Boston

WEIGHTED AVERAGE HARDNESS, BY STATES, OF WATER FURNISHED IN 1932 BY PUBLIC SUPPLY SYSTEMS IN OVER 600 CITIES IN THE UNITED STATES. From U. S. Geological Survey Water-Supply Paper 658.

parts per million for the period April 11-20, 1938 to 53 parts per million for the period June 1-10, 1938. A similar range for the Colorado River at Grand Canyon, Ariz., for the year ending September 30, 1934 was from 437 parts per million for the period May 21-30, 1934 to 1,889 parts per million for the period September 21-30, 1934.

The water from most wells is likely to be unchanged in composition over a period of many years. Analyses of samples from some wells and springs made 40 years apart have been as alike as analyses of two samples collected as nearly as possible at the same time. There are, however, places where the character of the water from a well has been changed completely because water of different composition has entered the water-bearing stratum or has entered the well through a leak in the casing that had been installed to keep out the heavily mineralized water.

Some wells near the sea have been contaminated with sea water when they have been pumped too heavily or when neighboring wells have been pumped so heavily that the salt water has entered the beds that formerly yielded fresh water.

Until the development of modern methods of water treatment, it was almost necessary for some industries to locate where the natural waters had much less hardness than the lowest residual that could be obtained by the use of the softening methods then available. Now it is commercially feasible to reduce the hardness to a point well below the hardness of the natural waters that were formerly the best that could be obtained.

The more rigid requirements of present manufacturing practice and the increasing number of commercial methods of water treatment have opened up a wide field for the application of special knowledge and skill in the use of such records as the Geological Survey and other organizations may have as to the industrial quality of the natural and treated waters available for use throughout the United States.

WATER QUALITY REQUIREMENTS FOR NEW ENGLAND INDUSTRIES

BY HERVEY J. SKINNER*

[*Read September 15, 1938.*]

Most of my listeners can hark back to the old days when water was water. Even today many people, unfamiliar with the nature of water and unmindful of the many advances that have been made in water works practice for their protection, are of the same opinion. How often we hear of someone who has found a spring or sunk a well on his property and brags about what wonderful water he has. The criterion by which he judges the water is color, clarity, and taste. It makes little difference to him whether there is a cess-pool, barnyard, or other source of pollution near the well, provided the water looks good and tastes good. If the surface of the lands slopes from the well toward the cesspool, then he is sure that the water is good, little realizing that the underlying strata may slope in the opposite direction from the surface. In industry we often find the same point of view.

Water is used in the industries for a variety of purposes. In many cases, its use is limited to fire protection or for cooling purposes where quality is not especially important. In other cases, where the water is used for process work, its quality is of prime importance and must be adapted to the requirements of each individual use.

In New England, the paper and textile industries are the largest users of water where quality is important. Laundries also require large amounts of water of suitable quality. Pulp and paper mills use considerably more water than raw material; for example, a mill making bleached pulp may use as much as five hundred or six hundred tons of water per ton of pulp. It has been estimated that in American fine-paper mills, using rags which require cooking, washing, and bleaching, the consumption of water may run as high as one thousand gallons per pound of dry paper produced.

A similar situation exists in textile mills. According to Matthews, the scouring and bleaching of woolen goods requires two thousand gallons of water for every one hundred pounds of woolen goods. Cotton goods require three thousand to four thousand gallons, and linen, ten thousand gallons per hundred pounds of product. From these figures it will be seen that the consumption of water in these industries is very large in proportion to the weight of material produced. No figures are available for laundries, but like any washing operation, large volumes are required.

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*President, Skinner & Sherman, Inc., Boston, Mass.

In other words, water is one of the raw materials of these industries, yet it is seldom so considered. If the mill operators of such plans would fix this fact in their minds and realize the importance of giving the same consideration to the water that they give to other raw materials, many troubles could be avoided, or at least minimized.

In earlier times, the necessity of water purification was not so vital, but with the increase in manufacturing activities, many waste materials find their way into the rivers and streams from which these industries draw their water. Pollution of streams is seldom constant so that there is a variation in the quality of water from day to day, and oftentimes from hour to hour. Furthermore, there is a variation between wet and dry seasons and between summer and winter.

When many of our New England industries commenced operations they used the water without any treatment. Some paper mills, where color or cleanliness of product is not a factor, still operate on raw water. As competition became keener, simple filtration to remove suspended matter sufficed. Then, in order to compete with some mills that had a colorless natural water, it became necessary to treat the water chemically to remove the color. Still later, it was found that the ever present slime produced by bacteria was a source of trouble, and chlorination became common practice. With the low-pressure steam boiler, mills were able to keep down the scale in the boilers with a little soda ash or other boiler compound, but with the advent of the modern high-pressure boiler, softening treatment became essential. Today, therefore, water is an important factor in nearly all manufacturing operations.

Characteristics of Water. In any discussion of water, a fundamental knowledge of its composition is essential.

In its natural state, water is never pure. Rain water is perhaps the purest form, but even in falling through the atmosphere, water dissolves oxygen, carbon dioxide, sulphur oxides, and other gases. It also contains minute quantities of nitrogen compounds such as ammonium salts, and dissolved organic matter, plant spores, and bacteria. Water holding in solution the gases which it has taken up from the atmosphere becomes an active solvent for the various minerals that make up the earth's crust, such as compounds of calcium, magnesium, iron, manganese, aluminum, silicon, sodium, and potassium. All water, therefore, contains these elements and to a less extent many others in amounts depending upon the character of the soil with which it has been in contact. Furthermore, as the descending rain, or snow, approaches the earth, it purifies the air and washes out of the atmosphere suspended particles of dust. These impurities, together with organic matter from vegetable organisms which develop and grow in the water, constitute what may be called "natural impurities" as distinguished from those derived from sewage and manufacturing wastes.

According to its source, water may be classified in general as rain water, surface water, and ground water. Rain water scarcely needs to be considered since it is seldom if ever available in quantities sufficient for manufacturing purposes.

Surface water includes the water from brooks, rivers, ponds, and lakes, and it is these waters that are most commonly used for industrial purposes. They contain all the "natural" impurities, are usually softer, and contain less mineral matter and more organic matter than ground waters. Suspended matter is often present, and in the case of swampy or peaty surroundings, the water may be more or less discolored. Surface waters will vary greatly at different times; this is particularly true of river waters which are influenced by rainfall, drought, and contamination from surface drainage, or from mill pollution.

Ground waters are those that come from deep wells and deep springs and on account of their long period of contact with the soil generally contain a larger amount of dissolved mineral matter. As a rule they are clear and free from suspended matter, partly on account of the lower content of organic and vegetable matter, and partly because of the filtering action of the soil.

Waters may also be classified as hard waters or soft waters. The constituents that make water hard are the salts of calcium and magnesium and to a less extent other dissolved mineral matter. Soft waters are those which are low in these constituents.

Qualities Affecting Paper and Textile Manufacturing. The basic raw material of both the paper and the textile industries is cellulose. The products handled by the laundries are also of cellulose; hence, the characteristics of the water used in these industries are very similar.

Those qualities which determine the suitability of water for these purposes are: (a) Color; (b) suspended matter; (c) iron; (d) manganese; (e) hardness.

Water of uniform composition and temperature is desirable, but these are conditions over which there is little control. Surface waters, for example, are influenced by rainfall, drought, and trade wastes. The variation in temperature from around freezing in winter to 70 or 80° F. in summer may cause variable manufacturing conditions. Plant and bacterial growth during the summer months is often the cause of annoyance.

I had occasion some time ago to do some work for a mill making a special fiber product. This mill always had trouble with spots on the product for about two months during the early part of the summer. About the first of August the trouble always cleared up. On investigation, it was found that these spots were due to bacterial growths that developed in the water at the summer temperatures. The mill was located in a hilly country and the river was fed by streams from the hills. Beginning about the first of August, the nights became cooler in the hills, with the result that the temperature of the water dropped below the point at which these organisms would develop.

Color. Water having little or no color is essential in the manufacture of paper or textiles. Pure water is colorless; but almost all natural waters, except sometimes those from deep wells and springs, have some color. In surface waters, all variations in color are found, ranging from almost colorless to a deep brown or red. The color of water is generally due to organic matter derived from vegetation, or to iron salts. In the case of some waters, the color of the water may be improved by simple filtration, but its complete removal requires chemical treatment. The amount of color permissible depends entirely on the product to be manufactured. For high-grade textile or paper products, it is desirable to have a water with a color of not over 5 p.p.m., as compared with the Platinum Cobalt Standards recommended by the American Public Health Association. This should be easily obtainable with proper chemical treatment.

Suspended Matter. Suspended matter is troublesome in the manufacture of paper, pulp, or textiles because it becomes entangled in the fibers, which act as a very efficient filter, thus causing spots and other imperfections in the finished product. Suspended matter nearly always is colored, so that its effect is closely connected with that of normal coloring matter.

The amount of suspended matter varies over wide limits, particularly in river waters, where it is influenced by the rains, which wash finely divided soil, leaves, and other foreign matter into the streams. Sewage and mill effluents, both of which are commonly discharged into rivers, also contribute to the suspended matter of surface waters.

Iron. The presence of iron is most objectionable since cellulose has the property of adsorbing iron and other metals from a dilute solution such as water. This adsorption of iron results in a yellowing of white papers or fabrics and in a dulling of colored products, particularly the more delicate ones.

Iron may be present in water in both the ferrous and ferric condition. In the case of ground waters, iron is usually in solution as ferrous carbonate, $FeCO_3$. The iron present in the soil is generally combined as ferric oxide, Fe_2O_3, and in this form is insoluble in water. If the water contains dissolved organic matter in appreciable amounts, the iron is reduced from ferric oxide to ferrous oxide; this combines with carbonic acid to form ferrous carbonate, which is soluble and goes into solution. When such waters come to the surface and are exposed to the air, oxidation takes place; the ferrous carbonate is decomposed, and is converted to ferric hydrate, $Fe(OH)_3$, which is insoluble.

In surface waters, the iron is nearly always present as hydrated ferric oxide, colloidally dispersed, although cases are known where trade wastes, such as pickling liquors from steel mills, are discharged into streams, and are responsible for the presence of ferrous iron.

Some years ago I had occasion to visit a mill making high-grade writing paper. The superintendent was an excellent paper maker. He had made paper in other locations but was unable to duplicate his results in this particular mill. He suspected the water, and had samples analyzed in his own laboratory and also sent some to independent laboratories, with the result that both pronounced it excellent for paper making purposes, provided that it was treated and filtered. On closer investigation, it was found that some miles above the mill there was located a steel plant which dumped large quantities of waste pickling liquor containing ferrous sulphate, a compound of iron in the reduced state. Ordinarily "ferrous" iron is not present in water as it is oxidized by the dissolved oxygen in the water, or by contact with the air, to form "ferric" iron, which precipitates as a red sediment and is easily filtered out. No test was made for ferrous iron; in fact, by the time the sample was analyzed it would all have been converted to the ferric condition. The distance, however, between the steel mill and the paper mill was not great enough for all the iron to become completely oxidized, with the result that the ferrous iron passed through the filters and later became oxidized and the paper discolored. When tests were made at the plant for ferrous iron, its presence was found and several vexing conditions explained.

Manganese. The presence of manganese in the water supply of a textile or paper mill may be exceedingly troublesome, and its importance has been quite generally overlooked. It is not a common constituent of water, but is found in certain localities at certain times of the year. The Connecticut River at Holyoke is a notable example.

Manganese behaves somewhat like iron, but it oxidizes more slowly and with the formation of the black hydrated oxide instead of the familiar red oxide of iron. It causes effects similar to iron as to staining and discoloration. It is also objectionable in bleaching operations, and if manganese-bearing water comes in contact with stock containing bleach, the chlorine will oxidize the maganese to permanganates which impart a reddish color to the fibers.

Manganese is more troublesome than iron because of the black oxide deposits which may cause clogging of pipe lines. An authentic case is on record of a public water supply containing 1.2 p.p.m. of iron and 0.8 p.p.m. of manganese which caused clogging of meters and service pipes in less than two years after they were installed. The material causing the stoppage analyzed 30 to 33% manganese and 12 to 15% metallic iron.

Amount of Iron and Manganese Permissible. The amount of iron permissible in water used for paper or textiles depends on the product to be manufactured. For high-grade papers, where color is a primary consideration, water that contains less than 0.1 p.p.m. of iron is desirable, although some high-grade writing-paper mills are operating satisfactorily with water whose iron content ranges from 0.1 to 0.2 p.p.m. In a properly designed plant for coagulation and filtration it should be possible to reduce the iron content to not over 0.05 p.p.m.

In the case of manganese, no figures are available as to a permissible amount. A bleachery, however, using water containing 0.3 p.p.m. of manganese, found that it was sufficient to stain the walls of the filtered water basin and to collect on the squeeze rolls of the washing machines. It may be safely stated that it is desirable to effect as complete removal of manganese as possible. If the hydrogen-ion concentration of the water is low, the manganese oxidizes very slowly, but in contact with alkaline surfaces such as concrete, the precipitation of the black hydrated oxide is more rapid and may give rise to "black water" complaints.

Hardness. In the manufacture of wood pulp, hard water is a distinct disadvantage. In the sulphite process, insoluble calcium and magnesium resinates are formed which deposit on the fiber and make subsequent bleaching difficult. In the alkaline soda process, calcium and magnesium salts are precipitated and carry down coloring matter also difficult to bleach.

In the paper industry, hard water is troublesome in the sizing and coloring operations, and while soft waters are desirable, they are not absolutely essential; excellent papers being made with relatively hard water that meets the other characteristics of freedom from iron, manganese, color, and suspended matter. Hard waters also tend to form scale wherever they are constantly in contact with metal parts. This scale breaks away and causes endless trouble in the product.

In the textile industry, soft waters are essential in many of the operations, especially where soap is used. The lime and magnesia which are mainly responsible for the hardness of water react with soap and form insoluble soaps, resulting in sticky curds that adhere to the fibers and are not easily removed by washing. These insoluble soaps are not only objectionable because of the defects in the finished product caused by them, but they render a considerable amount of the soap worthless. All of these soaps must be precipitated before any of the original soap becomes available for cleansing purposes.

In the processing of cotton, the cotton is first boiled with caustic soda to remove the waxy impurities. These waxes form soluble soaps with the soda, but if hard water is used, the insoluble lime and magnesia soaps are immediately formed with the same objectionable features as previously mentioned.

The cotton goods after washing are rolled up and allowed to stand. The water at the edges evaporates, leaving any metallic salts in the fiber. The edges, becoming drier, draw out fresh quantities of water from the inner portions by capillary attraction, and these deposit their dissolved salts near the edges as evaporation continues. In this way the selvages become mordanted, while the inner portions of the cloth are comparatively free from dissolved salts. If such goods are dyed, light or dark streaks develop along the edges, depending upon whether the metallic salts act as a resist or as a mordant for the particular dyestuff used, and there will be a shading from the edges to the center of the roll. If the goods are piled in folds, as is often the case, the edges of the folds will be the portions that dry more quickly, so that streaks running across the cloth at more or less regular intervals will result.

If cotton is to be mercerized by treatment with caustic soda, the precipitated soaps adhering to the fabric will cause uneven penetration of the caustic, resulting in a product which is not uniformly mercerized, and will cause uneven penetration of the dyestuff.

The fundamental process in the manufacture of woolens and worsteds is scouring, and upon its effective operation depends the success of the later stages of manufacture. The purpose of scouring is to produce a clean fiber free from all its natural impurities and is accomplished by washing with alkali and soap, which form soluble soaps with the fatty matter with which the wool fiber is coated. The combination of hard water with these alkaline soap solutions results in the formation of the insoluble lime and magnesia curds. The wool fiber is curly and has a rough surface which holds the curds very tenaciously and interferes with the subsequent operations of carding, spinning, and dyeing.

Hard water is also objectionable in the silk industry. The raw silk is first soaked, and if hard water is used, the calcium and magnesium salts are absorbed, which make the fibers hard and brittle and prevent smooth running of the fiber in the throwing operation, thereby increasing the breakage. In the degumming operation, soap is used, with the result that the troublesome insoluble soaps are formed.

In dyeing operations, one of the prerequisites is a clean fiber, hence the necessity of preparing the product to be dyed so that it will be free from impurities and above all, the insoluble soaps that resist the dyestuff and give uneven dyeing. Furthermore, many of the dyestuffs used in the textile industry react directly with the salts of calcium and magnesium of hard water and cause streaks and blotches in the dyed product. In dyeing fast colors, it is common practice to pass the dyed material through a boiling soap bath to remove any excess of dyestuff and to improve the finish. Here again hard water is obviously objectionable.

In the case of rayon, soft water is again necessary. Rayon is a completely manufactured product, and the water has just as much effect on the final product as the wood pulp or cotton used in its manufacture.

In laundries, soap and soda are employed in the washing process. When hard water is used, that portion of the soap which is precipitated as insoluble lime and magnesia soaps is a dead loss as it does not form suds and is of no value in cleansing the fabrics. A part of the soda is also wasted by reacting with the solids in the water and leaves undesirable deposits.

With raw water operations, the insoluble soaps are never completely removed. When the goods are ironed, these soap residues harden and reduce the life of the fabrics, as well as producing a gray tinge to white goods and a dull appearance to colored fabrics. Also, in the bluing and starching operations, these impurities coat the fibers and result in work of uneven appearance.

The curds are further troublesome as they coat the laundry wheels and extractors, contaminating the wash and preventing the laundry from doing its best work.

Purification of Water. The methods of purification will depend to a large extent on the particular water to be used. Waters that are low in the objectionable properties previously mentioned can sometimes be sufficiently improved for the purposes of many mills by passing the water through sand filters without chemical treatment. While this process is ordinarily referred to as "slow sand-filtration", it is essentially a straining process and should not be confused with coagulation and mechanical filtration, which will be described later. Slow sand-filtration or straining will remove suspended matter, unless it is colloidal in character. It will in many cases improve the color and sometimes lower the content of iron.

Coagulation and Mechanical Filtration. If the water contains appreciable amounts of impurities or if the requirements of the mill are such that high quality of product is essential, coagulation and mechanical filtration must be employed. The essential features are the addition of a coagulant, a period of settling for the elimination of most of the floc formed by the coagulation and filtration through sand filters at a rate considerably in excess of that obtained in an ordinary sand filter where coagulation is not employed. Color, suspended matter and iron may be effectively removed by mechanical filtration.

Manganese removal is more difficult and requires special treatment, such as forcing the water through a bed of pyrolusite which acts a a catalyzer and converts the manganese in solution to manganous hydroxide. This is oxidized to manganic hydroxide and manganese dioxide and may be filtered out. With some waters these oxidation reactions are interfered with by a number of factors such as free carbon dioxide, low total solids, low pH value, and organic matter. In such cases the zeolite principle has been found effective, and special zeolites are available for the removal of manganese. The design of a plant best suited for manganese removal involves experimental laboratory and field study, and the final design may include a combination of processes.

Coagulants. While there are a number of chemicals used for coagulation purposes, alum is the one most commonly employed. It has the advantage of being cheap, easily available, and with most waters satisfactory coagulation can be obtained under easily controlled conditions. The aluminum sulphate reacts with the metallic carbonates in the water and forms aluminum hydrate which is gelatinous in character. The positive aluminum ions also combine with the negatively charged ions of the colloidal color particles and of the silt in suspension. This hydrous aluminum oxide "floc" traps other silt particles mechanically and under properly controlled conditions collects in relatively large flocs that settle readily.

The alum is usually added in solution, and the proper dosage is controlled by the hydrogen-ion concentration. The optimum hydrogen-ion concentration, or the point at which the best floc formation occurs, varies with different waters and oftentimes with the same water at different times. It must, therefore, be determined in each individual case. Brom Thymol Blue is the indicator most generally used, since most waters fall within the range of 6.0 to 7.6. Cresol Red is used on more alkaline waters and Brom Cresol Green on acid water.

If the water does not possess sufficient alkalinity to react with the aluminum sulphate, soda ash may be added to effect the desired coagulation. In the case of very alkaline water, the amount of alum necessary to neutralize the alkalinity of the water may be excessive, in which case sulphuric acid is added to neutralize a portion of the alkalinity before the alum is added, thus effecting a saving in the cost of treatment.

Ferric chloride and ferric sulphate are becoming popular coagulants and have the advantage of forming a compact and easy settling floc at any pH above 3.5 making them practical over a wide range of hydrogen-ion concentration.

Sodium aluminate is another coagulant that has come into use during recent years. It is most effective with waters of low pH which require the use of an alkali like soda ash in order to produce a satisfactory floc. The choice of coagulants is governed by the characteristics of the water to be treated and by economic conditions.

After the coagulating chemicals are added to the water, agitation is necessary to cause the proper formation of floc. The design of the mixing chamber is very important since the best floc formation is governed by the time and character of the agitation.

Sedimentation. From the mixing chamber the water passes to the sedimentation basin which should be of such size as to permit the floc to settle in the time that it takes for the water to travel through the basin. The time of settling varies from thirty minutes to three or four hours, according to the character of the water. Usually a detention period of from two to three hours is required. From the sedimentation basin the water passes to the filters.

Filtration. There are two types of sand-filters—gravity and pressure. The filter medium of sand is the same in both types and the principal difference is that the gravity filter is an open concrete tank, whereas the pressure type is a closed steel tank. Pressure-type filters occupy less space and do not necessitate repumping the water. As a rule the first cost is less than for gravity filters.

The systematic washing of the filters by reversing the flow is important, and the filters should be opened up periodically and if necessary given a caustic soda wash. I recently had occasion to make a survey of a paper mill and found that the filters had not been opened up in ten years.

Chlorination. All surface waters and occasionally ground waters contain bacteria in varying numbers. These bacteria develop and accumulate in pipe lines and cause slimy deposits. This is particularly true in paper mills, especially where a portion of the water is recirculated and used over again.

The universal use of chlorine for the sterilization of public water supplies suggested the use of chlorine to reduce the number of bacteria in the water supply of pulp and paper mills, and its use has become quite general, either as liquid chlorine or as chloramine. The latter is better adapted for use in pulp and paper mills because of its longer sterilizing action.

Corrosion. Water is corrosive and it is sometimes necessary to apply a corrective treatment. Most waters contains dissolved oxygen and free carbon dioxide which are factors in causing corrosion. In the mechanical treatment of water, especially when alum is used as the coagulant, the amount of carbon dioxide is increased in proportion to the alum used and requires correction by neutralizing with alkali.

Carbon dioxide also is a factor in accelerating the corrosion of metals. It dissolves in water, forming a weak acid which increases the hydrogen-ion concentration of the water. If the water contains bicarbonates of calcium and magnesium, a portion of the carbon dioxide is required to hold these in solution. Any excess is free and known as "aggressive" carbon dioxide. Hard waters, for example, may contain appreciable amounts of carbon dioxide without becoming aggressive, whereas soft waters may be aggressive with relatively small amounts of carbon dioxide.

Under ordinary conditions, increased acidity or hydrogen-ion concentration stimulates corrosion by preventing the formation of protecting films or by removing them. Free acids are seldom found in water unless contaminated trade wastes, but if present, they increase corrosion by evolution of hydrogen and depolarizing the metal surfaces. Alkalies which are more likely to be present in water reduce the hydrogen-ion concentration and make the water less corrosive. If the hydrogen-ion concentration is increased, the corrosive effect is more marked at high temperatures, and the velocity of the water through pipes also increases corrosion due to the removal of protective films that may form.

Water Softening. It is not as a rule economically feasible to soften the water for a pulp or paper mill. It is desirable, however, in some cases to soften that portion which is used for sizing purposes, and in most cases that portion used for steam boilers. With textile mills it is desirable, and in fact necessary to apply softening treatment for a large portion of the water used.

The methods most commonly used for water softening are the precipitation process and the zeolite process. The lime-soda process involves precipitation of the calcium and magnesium salts with lime and soda. The zeolite process is based on the exchange principle, the zeolites having the property of exchanging a part of their sodium for the calcium and mangnesium of the water. With the zeolite process it is possible to reduce the hardness to practically zero, whereas with the lime-soda process the practical limit is about three to five grains per gallon.

The choice between these two methods or possibly a combination of the two depends on the character of the water to be treated and the nature of the process in which the treated water is to be used. In general the lime-soda process requires more attention as the additions of chemicals have to be varied according to the hardness of the water. The size of a lime-soda softener is determined by the amount of water regardless of its hardness, whereas the size of a zeolite softener depends on the hardness and the rate of flow. In the case of turbid waters or waters containing free acid or iron, the lime-soda process would be preferable unless the zeolite softener is used in conjunction with mechanical filtration.

Heretofore the zeolites have been of a silicious nature and have reduced the hardness to a minimum without changing appreciably the total solids. More recently the carbonaceous zeolites have been developed as a result of research and are now available. These zeolites retain the simplicity and complete hardness removal properties of the silicious zeolites, and have in addition the property of eliminating the alkalinity with a corresponding reduction in total solids.

With the silicious zeolites the calcium and magnesium alkalinity was transformed to sodium alkalinity, which in many cases was objectionable, but the removal of this soda alkalinity by the carbonaceous zeolites is distinctly advantageous in the treatment of water for many purposes.

Importance of Water Control. The author's contact with industrial plants emphasizes the fact that those responsible for their management do not sufficiently appreciate the importance of the quality of the water used in their processes. In the early days of the paper and textile industries, the requirements as to quality in the product were not particularly rigid, and it was easily possible to get along if the water from the streams was soft and reasonably clear. With increasing competition, specifications became more severe, and a mill having a water which, for example, contained more iron or was more highly colored than its neighbor's had difficulty in delivering a product of the required degree of whiteness. Recently the writer had occasion to examine the water from two plants, both making the same kind of material. The water in one plant and a low color, whereas the water in the other plant had a relatively high color. The latter plant was operating on untreated water, but the more rigid requirements brought about by competition forced them to install a complete plant for purifying their water supply.

This emphasizes the importance of having a full knowledge of all the conditions before reporting on the suitability of a water for a given purpose. It is more or less common practice to submit a sample of water to a chemical laboratory for analysis and an opinion as to its suitability. The interpretation of the analysis should be made by an engineer who has specialized on water problems, and who has investigated the supply from which the water was taken. In addition he should be familiar with the conditions under which the water is to be used in order to advise proper purification.

The importance of engineering assistance in the design and operation of water-treating plants cannot be emphasized too strongly. The author knows of an instance where the water from the sedimentation basin was pumped a distance of several hundred feet to the filters and on the way was passed through the condenser of a turbine engine for cooling purposes. The process of coagulation and sedimentation is based on keeping the water moving at a low velocity in order that the precipitated floc may be as large as possible. Pumping the water through a condenser resulted in breaking up the floc, thus undoing much of the work of the settling basin.

There are, as you all well know, many manufacturers of water equipment who render complete engineering service, but it should be recognized that they all have something to sell. It should be borne in mind, furthermore, that they do not always have facilities for testing out new ideas, in fact it would not be practical for them to do so on account of the variety of conditions that they are required to meet. The result is that new ideas are sometimes tried out at the expense of the purchaser of equipment, and if they are not successful, a controversy results. The writer has seen instances where this very thing has happened, and in at least one instance a lawsuit was instituted by the purchaser on the ground that the conditions guaranteed by the manfuacturer were not fulfilled. This situation emphasizes the importance of having an experienced engineer pass on the design of equipment before a purchase agreement is signed. It is also important that the treatment of water should be considered as a chemical engineering operation and should be under the control of the chemical staff of a mill.

Not long ago the writer heard of a case where a coagulation and sedimentation treatment was put into operation by the engineer of the company installing the equipment. About a week or ten days later, he returned to find out how the plant was working, and found to his amazement that the foreman in charge had disconnected the chemical feeds, and was simply passing the water through the filters without any coagulating treatment. Upon inquiry it was learned that the man in charge thought that the filters were taking out too much dirt and that he had to wash them too often.

This incident illustrates a situation which is prevalent in too many mills. A friend of mine once said that "technical control did not mean the employment of a chemist just out of college who reported results which were probably erroneous to an executive who didn't understand them."

Every plant operating any process of a chemical nature should have a qualified engineer on its staff or as a consultant. It is well known that there are many manufacturers who have made money in the past but who are unable to do so under present competitive conditions. In a number of instances this is due to the fact that fine points of operation have been neglected, among which may be mentioned the proper treatment and utilization of their water supply. The successful manufacturer of today insures the continuation of profitable operation by instituting technical control under the supervision of a competent engineer.

DISCUSSION

E. SHERMAN CHASE.[1] What is the limit for alum which may pass through a filter plant before trouble may be experienced in the process of dyeing in the textile industry?

SHEPPARD T. POWELL.[2] My experience has been that it depends entirely on what condition the alum is in. If the alum goes through as a floculate material or is floculated after it passes the filter, I think most any amount would give trouble, and the degree of trouble would depend on the amount that goes through and the conditions in the mill proper. If the alum is in true solution and will not be precipitated afterwards, I don't think there will be very much trouble.

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[1] Of Metcalf and Eddy, Boston, Mass.
[2] Baltimore, Md.

Conditions in mills vary so greatly that what might be tolerated in one mill might give very serious trouble in another mill. I think Mr. Skinner will bear me out that the product itself has a lot to do with it. If you are making a high grade, very fine white paper, you will only want a small amount; if you are making a paper in which color is not so important you can stand more before you get into trouble.

MR. SKINNER. In the case of paper, the residual alum, not floculated, would not cause very much trouble, except perhaps in special papers, because alum is added in connection with sizing. In recent years there has been a tendency to reduce the amount of alum used, as an excess causes the paper to become brittle with age. The size is precipitated with alum at a pH around 5 so that some alum is left in the paper.

F. J. LAMMERS.[3] The mills, especially in this area, which are using the new alpha cellulose pulps, will find for rayon production that they have to have an extremely low ash. In that case not only the usual characteristics of the water are important but also the total solids content, because the amount of solids dissolved by the water into the fibre actually jacks up the ash content. In that case not only the ordinary elements but special carbonaceous zeolites and resinous zeolites may be important.

EDWARD W. MOORE.[4] A figure for water consumption in wool scouring of about 20 gallons per pound of wool is sometimes given. It seems to me that I have seen figures as low as a gallon of water per pound of wool for recirculation systems. Are those figures creditable?

ROBERT SPURR WESTON.[5] A test made by one of the largest wool combing plants in New England showed 1.6 gal. per pound of wool, and I have been advised that this mill is using less than that now. Another mill that I know uses 0.8 gal. per pound of wool and thinks anything more than one gallon of water per pound of wool on a grease wool basis is wasteful.

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[3] Of International Filter Company, New York, N. Y.

[4] Harvard University, Cambridge, Mass.

[5] Boston, Mass.

THE TREATMENT OF WATER FOR INDUSTRIAL AND BOILER FEED USES

BY SHEPPARD T. POWELL*

[Read September 15, 1938.]

The primary object of many members of this Association and similar groups is the development, purification and delivery of adequate water supplies for municipal uses. Fundamentally, such water must be safe for human consumption and esthetically acceptable with respect to its physical and chemical characteristics. The fulfillment of these requirements is generally recognized as an adequate accomplishment, beyond which the water works operator has no further responsibility. From an economic viewpoint, however, the treatment of water for industrial uses is a closely related problem which may not be ignored by water works management and, although of less civic importance than water works engineering for sanitary and fire-prevention purposes, it should nevertheless be recognized. It is unreasonable to expect that a public water supply should be delivered to various industries, in such condition that it will be generally satisfactory to all without further treatment. As industry has developed, the demands for quantity and quality of water have become increasingly important. This is especially true in highly industrialized centers and where the products manufactured require water of a particular degree of purity.

Management of public water supplies has a definite, if limited, responsibility to industrial consumers. In many communities such consumers provide a relatively high percentage of the gross water works revenue, either in the form of taxes or payment for purchased water. Consideration of their requirements, therefore, is a logical and reasonable concession. Too often the planning of water works systems and adoption of treatment processes have been consummated with only minor consideration of this class of consumer. The purpose of the speaker's foregoing comments is merely to direct attention to this phase of water works engineering as a preface to a discussion of the treatment that industries themselves may provide and of recent advancement in the art.

Because of the wide variation in the quality of water desired in different industries, the water treating processes employed cannot be standardized. In the final analysis, the selection of each treatment plant must be determined by specific requirements and local conditions. Almost every industry has an individual specification for its process water, and it is possible here only to indicate briefly the groups of industries to which specific characteristics of water quality are of special importance.

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*Consulting Chemical Engineer, Baltimore, Md.

The need for water in all manufacturing plants may be broadly classified under three headings, namely: (a) for cooling or condensing purpose, (b) for processing, and (c) for steam generation.

Cooling and Condensing Water Supplies. The characteristics of primary importance for water in this group are the temperature and turbidity of the supply. Although temperature is not related to water conditioning, it has an important economic aspect and frequently outweighs all other desirable requisites in the selection of a supply. This problem is not as generally recognized as might be expected. W. D. Collins has directed attention to this matter in the comprehensive bulletin published by the U. S. Geological Survey in 1925. In the opening sentence of this monograph the author stated: "The importance of water supply as a limiting factor in industrial development is becoming more evident each year. The limitation in a particular instance may be the quantity of water available, the quality determined by the mineral matter in solution or in suspension or by organic pollution, or the temperature of the water. Generally it is a combination of two or more of these factors. The temperature of these waters is discussed in the present report."

The regulation of the temperature of a public water supply is not possible, since it is governed by a number of uncontrollable factors. Industrial requirements in this respect may be fulfilled in many communities by preferential apportionment or allocation of underground water supplies for industrial uses. As is well known, the temperature of such water is much lower and more uniform than the temperature of surface water and, therefore, it is generally preferred for cooling or condensing purposes.

In a few instances municipalities have recognized this economic phase of the problem, but such action is rare. In one large community in the Southwest, replacement of the city's underground water supply by a surface supply is being considered, in order to conserve the well water to meet the requirements of the large and growing industrial development that is now in progress.

A certain amount of turbidity, suspended matter and microorganisms can be tolerated in water that is to be used solely for cooling purposes. Excessive amounts of such foreign matter, however, cannot be present in the supply without imposing financial losses resulting from poor heat transfer in cooling systems and high operation and maintenance charges on equipment. Ordinarily, clarification of cooling water is not justified, except where the supply contains excessive amounts of turbidity or other suspended solids. There is a growing demand, however, for the maintenance of clean heat exchange surfaces, and the solution of this problem has been furthered by the increased use of chlorine for removal of slime from condenser tubes and the presettling of cooling-water supplies to remove gross amounts of suspended solids. In many instances softening plants have been installed to prevent the deposition of scale in such equipment. Where such treatment has been inaugurated, recirculation and cooling of the water is practised in order to keep the cost of water within economically practicable limits. Generally, however, the undesirable qualities of water may be overcome by the installation of screens or other types of strainers to remove the coarser suspended solids.

Chemical Treatment and Filtration. Coagulation and filtration are the most extensively used methods of purification of water for process uses. Treatment of industrial water in this manner is similar to that which is practised in the preparation of water for sanitary purposes and requires no specific discussion before this group. However, in the case of industrial water, stricter specification with respect to color, turbidity, manganese and iron removal have led to more efficient pretreatment and the adoption of chemical coagulants best suited to bring about the desired results.

Much ingenuity has been demonstrated by industrial engineers in the arrangement of settling basins and flocculating appliances leading towards improved operation of equipment and reduction in the general cost of maintenance and control. Where it has been possible to use circular steel or wooden tanks, a number of designs have been developed that have produced gratifying efficiencies. One arrangement for baffling of a circular tank that has proven highly efficient with respect to removal of suspended solids is shown in Figure 1. This tank provides for the admission of the raw water and chemicals into a mixing and flocculating chamber whereby the coagulated water is properly prepared. The water so treated leaves the mixing chamber on each side and flows into baffled influent compartments. The water from these compartments flows into the main settling section located on either side of the tank. In order to secure straight-line distribution, the water flows over submerged stilling baffles and passes in a straight flow across the tank to the opposite side, where the

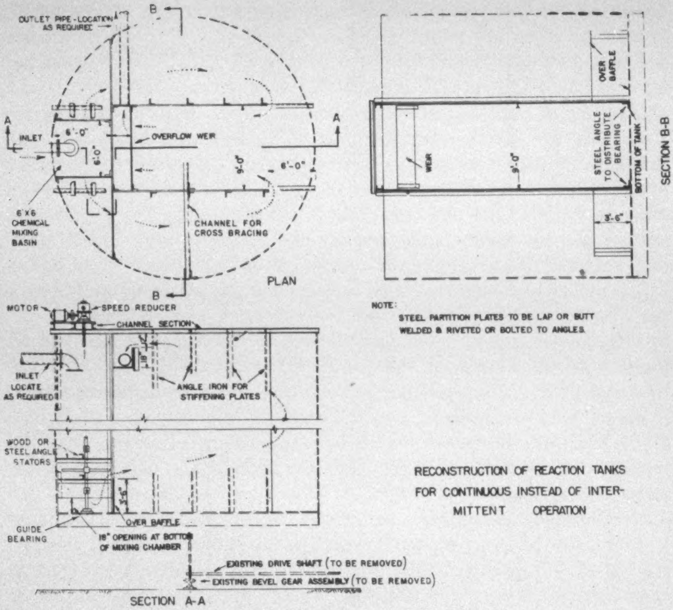

OUTLET PIPE-LOCATION AS REQUIRED
B
A
INLET
6'-0"
6'-0"
OVERFLOW WEIR
9'-0"
6'-0"
6'X6' CHEMICAL MIXING BASIN
CHANNEL FOR CROSS BRACING
B
PLAN
OVER BAFFLE
STEEL ANGLE TO DISTRIBUTE BEARING
BOTTOM OF TANK
WEIR
9'-0"
3'-6"
SECTION B-B
MOTOR
SPEED REDUCER
CHANNEL SECTION
INLET LOCATE AS REQUIRED
18"
ANGLE IRON FOR STIFFENING PLATES
WOOD OR STEEL ANGLE STATORS
3'-6"
OVER BAFFLE
GUIDE BEARING
18" OPENING AT BOTTOM OF MIXING CHAMBER
EXISTING DRIVE SHAFT (TO BE REMOVED)
EXISTING BEVEL GEAR ASSEMBLY (TO BE REMOVED)
SECTION A-A
NOTE:
STEEL PARTITION PLATES TO BE LAP OR BUTT WELDED & RIVETED OR BOLTED TO ANGLES.
RECONSTRUCTION OF REACTION TANKS FOR CONTINUOUS INSTEAD OF INTERMITTENT OPERATION

FIGURE 1.

direction of flow is again diverted by means of a directional baffle. From this point the water again passes in a straight line to the skimming weir, from which it is discharged to the filters. By means of a sludge-removal system in the bottom of the tank, the accumulated deposited solids can be removed without taking the unit out of service. This design is a slight modification, with respect to influent and effluent weirs, of one which was originally devised by W. T. Sherman, Power Engineer of the Socony-Vacuum Oil Company, and his associates. It has proven effective in the pre-treatment of turbid waters and has been used also for the removal of coagulated oil prior to filtration. The construction is less costly than for many other types, since it permits the use of standard circular tanks which may be either of riveted or welded steel or of wood. The baffles may be readily placed if wooden-stave tanks are used.

The unusual baffling arrangement of a circular tank illustrated in Figure 2 was developed as a result of extensive pilot-plant investi-

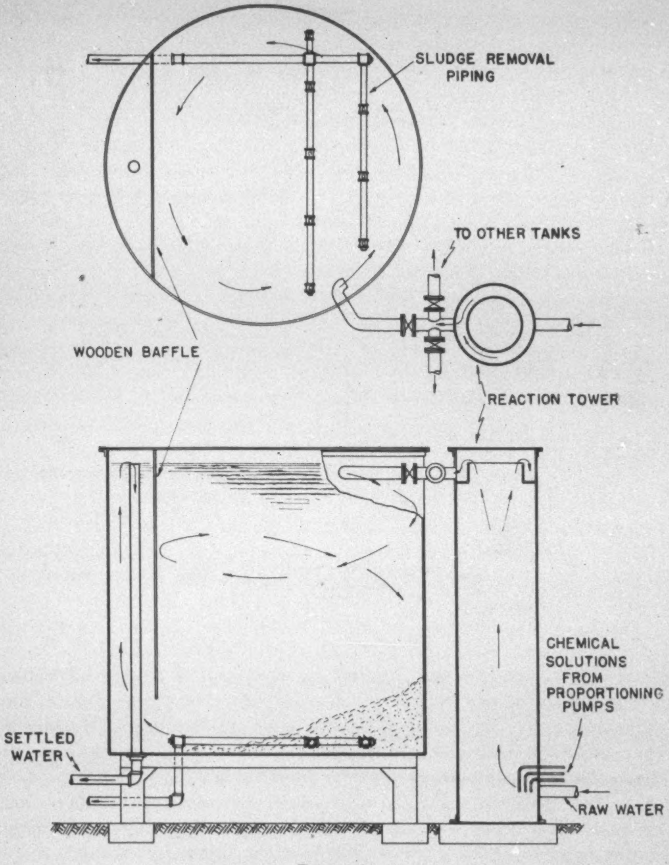

SLUDGE REMOVAL PIPING
TO OTHER TANKS
WOODEN BAFFLE
REACTION TOWER
CHEMICAL SOLUTIONS FROM PROPORTIONING PUMPS
SETTLED WATER
RAW WATER

FIGURE 2.

gations of several different designs, prior to the reconstruction of a series of fill-and-draw tanks to adapt them to continuous-flow operation. It will be noted that provision is made for the entrance of the water at the top of the tank directly opposite the baffled outlet section. The water enters tangentially and flows in a circular direction and downward across the tank, permitting the deposition of solids or sludge on one side of the tank, leaving the water relatively free from suspended matter by the time it passes up under the baffle and leaves the take-off weir. The flow is indicated by the arrows shown in the figure. Excellent results have been obtained from this tank, and its efficiency in the removal of suspended solids has been much greater than was previously obtainable from the same tanks operated on a fill-and-draw principle, when they had a capacity sufficient to permit more than four hours of quiescent settling. It is of interest to note that this reconstruction of the system was less expensive than other designs that were studied. The experimental studies leading to this design were conducted by Ralph McCumber, I. G. McChesney and Frank Henry, of the Rochester Gas and Electric Corporation.

The author assumes that the majority of engineers present are familiar with the developments in coagulation and pre-treatment of water based on causing the water to flow through a sludge blanket that is maintained in the reaction and settling tanks. Two types of equipment utilizing this principle are presented here merely to point out their application to treatment of industrial waters. Figure 3 shows the construction of the tank developed by C. H. Spaulding for softening with lime, in which process the repeated contact of the water with the precipitated sludge assures an effluent that is stable with respect to the solublity of calcium carbonate. In the operation of this tank the treated water enters the inverted cone at the center and is stirred with paddles to effect flocculation of the coagulated precipitate. The water, containing that part of the floc which has not settled out, passes upward through an annular opening into the outer part of the tank, which is formed by the central upright cone and the outer inverted cone. The cross-section of this part of the tank increases as the elevation increases, and as the water flows upward its velocity is reduced accordingly. At a certain elevation the velocity is just sufficient to support the floc, which therefore forms a blanket at this point below a top layer of relatively clear water. The height of the sludge blanket is governed by the rate of flow through the plant and the withdrawal of excess sludge. The scrubbing of the water by the blanket of floc during its upward passage through the cone assures a completeness of reaction and retention of suspended matter that is not ordinarily obtainable in standard subsidence basins. The relative dimensions and angles shown here are those which were found to be best suited to the softening of a particular water supply by means of lime and a coagulant. For other purification processes in which the characteristics of the sludge and density and viscosity of the water are different, it may be necessary to introduce wide

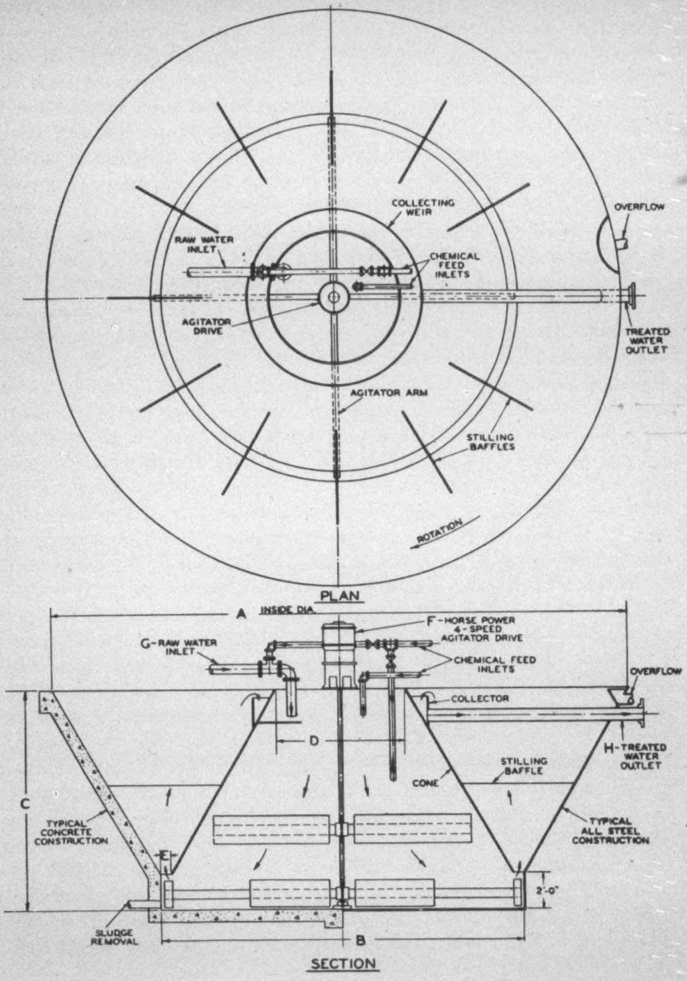

COLLECTING WEIR
OVERFLOW
RAW WATER INLET
CHEMICAL FEED INLETS
AGITATOR DRIVE
TREATED WATER OUTLET
AGITATOR ARM
STILLING BAFFLES
ROTATION
PLAN
A
INSIDE DIA.
F-HORSE POWER 4-SPEED AGITATOR DRIVE
G-RAW WATER INLET
CHEMICAL FEED INLETS
OVERFLOW
COLLECTOR
D
H-TREATED WATER OUTLET
STILLING BAFFLE
CONE
C
TYPICAL CONCRETE CONSTRUCTION
TYPICAL ALL STEEL CONSTRUCTION
E
2'-0"
SLUDGE REMOVAL
B
SECTION

FIGURE 3.

variations in the rate of flow, angle of the cone, and mixing and sludge-removal facilities.

A reaction and settling tank utilizing the principle of recirculation of sludge has been patented by W. H. Green and A. S. Behrman, and is called an "Accelator" to emphasize the acceleration of the water purification process that may be accomplished with this equipment. A schematic diagram illustrating its operation for cold process lime soda softening is shown in Figure 4. The chemicals are added directly to a relatively thick concentration of precipitated sludge near the bottom of the tank, and the raw water is treated with this mixture and is stirred at a higher velocity than is commonly employed in coagulating tanks. It is the purpose of this design to bring about the initial softening reaction in the presence of sludge so that precipitation takes the form of accretions to existing particles, rather than the formation of new particles of much smaller size. From the primary mixing and reaction zone, the water flows upward into a final mixing and reaction zone, carrying with it a high concentration of sludge that is kept suspended by relatively rapid mixing. Flowing downward out of this area, the water enters an outer section of much larger diameter which is free from turbulence and which permits the much slower upward flow of the water to a take-off weir. The sludge settles out and is returned to the bottom of the tank, or is skimmed off into a concentrator compartment and removed continuously. Without detailed analyses of the several effects that contribute to the efficiency of this apparatus, it may be stated that the capacity is based on the area of the slurry zone from which the clarified water rises, and that large areas based entirely on detention time are not

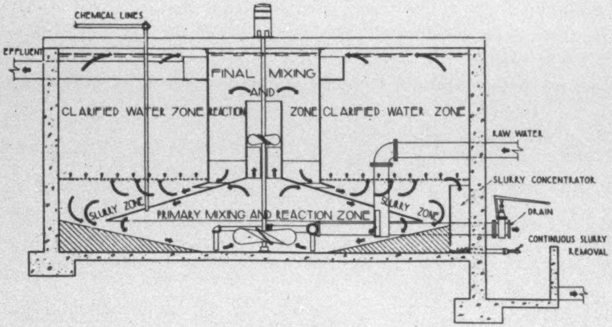

CHEMICAL LINES
EFFLUENT
FINAL MIXING AND REACTION ZONE
CLARIFIED WATER ZONE
CLARIFIED WATER ZONE
RAW WATER
SLURRY CONCENTRATOR
SLURRY ZONE
SLURRY ZONE
PRIMARY MIXING AND REACTION ZONE
DRAIN
CONTINUOUS SLURRY REMOVAL

FIGURE 4.

required. As in the case of the Spaulding conical apparatus, the Accelator would be susceptible to modification to adapt it to treatments other than cold process softening.

These two designs of equipment, based on the principle of filtration through sludge, are presented here because of their application for the treatment of industrial waters. Both of these types of tanks have been studied to determine their efficiency for the removal of silica from water for boiler feedwater uses, and the results obtained have shown them to be more effective than the standard design of tanks that were considered. One large plant is now being designed which will utilize this principle, and at several other places similar studies are being conducted. Some of these plants have been installed, also, for removal of turbidity and for softening the water used for paper making and other industrial purposes.

It is predicted that tanks operating on the sludge-blanket principle will have an increasing use in the treatment of industrial water because of the several inherent advantages offered by this type of equipment. Some of the special claims made for this equipment are:

A. Greater efficiency in the removal of suspended solids per cubic foot of tank capacity.

B. Reduction in pumping cost because of the reduced height of the tank.

C. Higher softening efficiency per unit when the tanks are used for this purpose.

D. Economy of operation of filters due to a more adequately prepared water prior to the discharge of the filters.

The author's experience with equipment of this type demonstrates that the chemical and physical principles upon which the designs are based are sound, and where the apparatus is found to be adapted to local conditions it may prove to have advantages over many other forms of reaction and settling tanks. However, other forms of tanks whose merits have been proved by ample experience should be given thorough consideration in any study preliminary to the design of a water treatment system. Attention has been drawn to these newer processes as an illustration of developments in the art which broadens the field of choice of equipment.

Designers of filtration equipment for the treatment of industrial water supplies have drawn largely upon the experience of sanitary engineers and the developments in the sanitary field. The major difference is the widespread use of pressure filters for the treatment of industrial waters, a type of equipment which is seldom acceptable for the preparation of water for domestic consumption. Although many engineers recognize the limitations of pressure filters, such appliances are nevertheless widely used because they are less expensive to install than gravity filters, require less space, and often eliminate the necessity for secondary pumping. Improvements in the design of such equipment have been along the lines of the use of better materials, new types of filter media and trends to lower rates of filtration.

Industrial water treatment often requires the use of filter media other than sand, which is so widely employed in municipal filtration plants. The reason for the rejection of sand as a filter medium is the required limitation of the silica content of water used in certain industrial processes, particularly in the preparation of water for steam-generating purposes. In place of sand, anthracite coal, calcite and magnetite, are used. In the past, calcite has been widely employed for the filtration of water from hot chemical softeners. In recent years there is a trend towards the use of anthracite coal for this purpose. This filter material, either alone or in combination with graded magnetite, has proven a very acceptable product. Graded magnetite which contains a relatively small amount of silica and is free from sulphur compounds has many advantages over some of the other filter media. However, this is a costly material, and for this reason its use is limited to certain conditions where other materials may not give as satisfactory results. Recent experience has demonstrated that graded magnetite is not a satisfactory material for filtration of water containing phosphates, and in at least one case it has been shown that filtration of such water through a magnetite bed cemented the upper layers of the magnetite into a hard mass. This difficulty can be avoided by using magnetite for the supporting medium for graded anthracite coal. In designing filters using anthracite coal or a combination of magnetite and anthracite, special attention should be given to the proportions of the tanks, which should be so constructed as to provide ample freeboard for expansion of the filter medium. In using magnetite for the filtration of hot alkaline water it is necessary to select the material carefully and avoid products that contain sulphur compounds. Run-of-mine magnetite containing such compounds imparts soluble sulphides to the treated water. The various sulphur compounds dissolved from the magnetite break down when the temperature of the water is elevated and are released in the form of hydrogen sulphide.

The design of industrial water purification plants has permitted engineers a much wider selection of materials than is possible in the sanitary field. The preference for the use of specific materials in the industrial field depends on the severity of the specification for water quality and the permissible cost of the systems. In such plants, construction of all-steel, wood, or concrete may be used. An illustration of an all-steel treating plant for the removal of oil from condensate is shown in Figure 5. This plant consists of a baffled circular mixing, coagulating and settling tank, and circular gravity steel filters, using magnetite and anthracite coal as the filter medium. The entire system is of welded steel construction and is relatively inexpensive to build, but has given excellent results. The oil in the contaminated condensate treated by this system varies from 50 to 300 p.p.m., while the oil in the effluent varies between 0.2 and 0.5 p.p.m. Ferrous sulphate and soda ash are employed as coagulants.

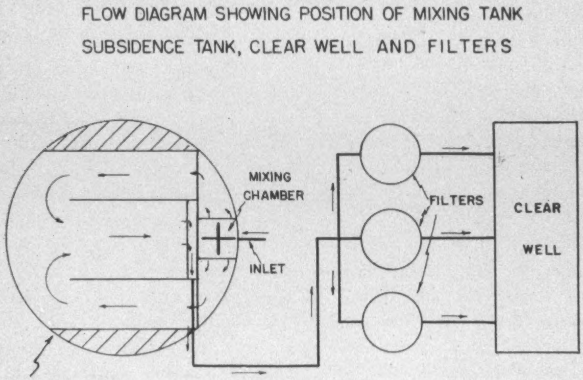

FLOW DIAGRAM SHOWING POSITION OF MIXING TANK
SUBSIDENCE TANK, CLEAR WELL AND FILTERS
MIXING
CHAMBER
INLET
FILTERS
CLEAR
WELL

FIGURE 5.

Water Softening. Industrial water softening may be accomplished by either chemical precipitation or the use of base exchange materials. The fundamental principles of operation of these processes are well understood by water works engineers and do not require discussion by the author. Recent developments in this field have been along the line of combination systems, improvement in the design of equipment and more efficient softening materials. The adoption of a particular system for the softening of water must be governed by local conditions and economies that may be effected in the construction and subsequent operation of the plant. If the plant requirements are for hot water, hot-process chemical softeners may be employed, although in some instances the softening may be effected by base

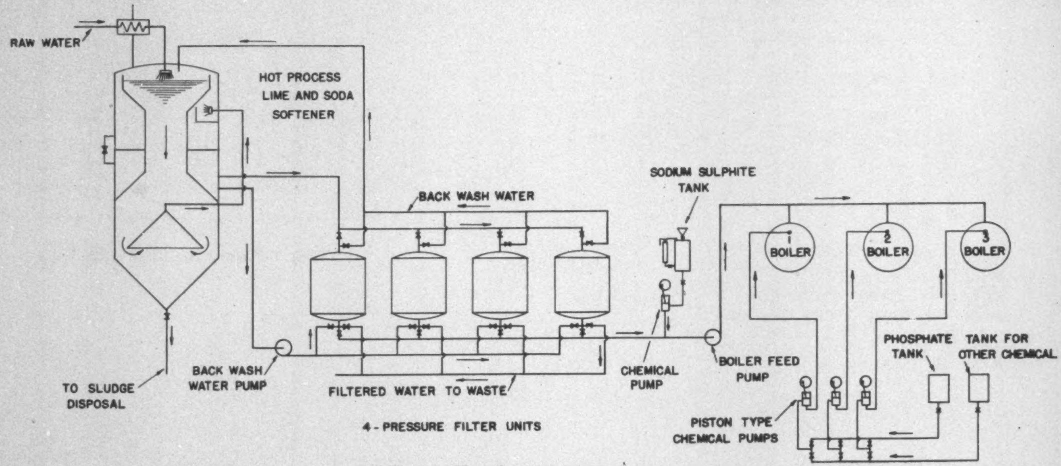

RAW WATER
HOT PROCESS
LIME AND SODA
SOFTENER
BACK WASH WATER
SODIUM SULPHITE
TANK
1 BOILER
2 BOILER
3 BOILER
PHOSPHATE
TANK
TANK FOR
OTHER CHEMICAL
TO SLUDGE
DISPOSAL
BACK WASH
WATER PUMP
FILTERED WATER TO WASTE
CHEMICAL
PUMP
BOILER FEED
PUMP
4-PRESSURE FILTER UNITS
PISTON TYPE
CHEMICAL PUMPS

FIG. 6—HOT LIME SODA SOFTENING.

FLOW DIAGRAM OF LIME - SODA, HOT PHOSPHATE BOILER FEED WATER SOFTENING SYSTEM

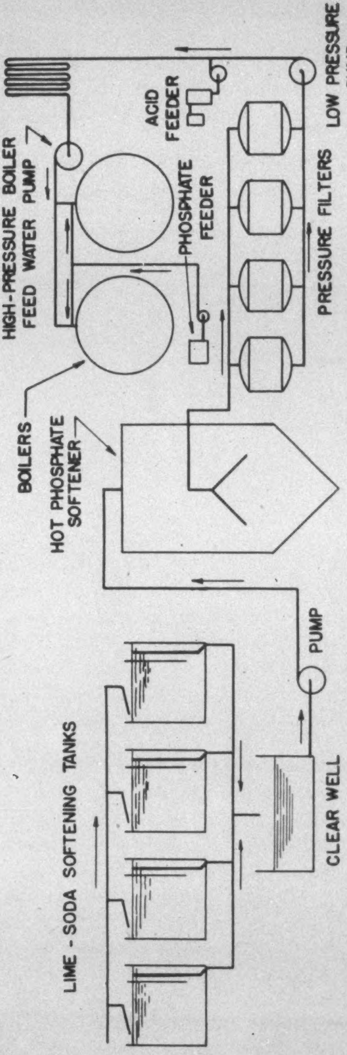

LIME - SODA SOFTENING TANKS
CLEAR WELL
PUMP
HOT PHOSPHATE SOFTENER
BOILERS
PHOSPHATE FEEDER
PRESSURE FILTERS
HIGH - PRESSURE BOILER FEED WATER PUMP
ACID FEEDER
LOW - PRESSURE ECONOMIZER
LOW PRESSURE PUMP

FIGURE 7.

exchange materials while the water is cold, the subsequent elevation of the temperature of the soft water being accomplished by heaters or heat exchangers. Recent improvement in hot chemical softeners has been related largely to the internal arrangement of the softening tanks, apparatus for heating, and chemical feeding devices. Figure 6 shows a recently designed softener for the treatment of boiler feedwater for a high-pressure plant. The novel features of this design are the inclusion of a separate clear water tank for filter backwashing use. The purpose of this arrangement is to insure backwashing of the filters with clear deaerated water and to return the dirty water to the tank without materially changing the rate of flow through the system or upsetting the normal functioning of the apparatus.

A recently designed treating system embodying a combination of semi-hot lime-soda softening and hot softening by means of phosphates is illustrated in Figure 7. The raw water supplied to the system is a hard water fluctuating widely in turbidity and mineral salts. The pre-softening is effected by means of continuous flow tanks of the type shown in Figure 2, referred to before, providing for the withdrawal of the softened water under a submerged weir. The clarified and partially softened water is then pumped to a standard hot-process softener in which practically complete removal of hardness is obtained by use of di-sodium phosphate. The effluent from this softener is discharged through pressure filters containing magnetite and anthracite. The pH of the water so treated is then reduced by means of sulphuric acid before it is used for boiler feed. The purpose of the sulphuric acid is to prevent the precipitation of tri-calcium phosphate, which will occur if the pH value of the water is much in excess of 9.0. The chemical analysis of the raw and treated water is shown in Table 1.

TABLE 1—COMPOSITION OF WATER AT VARIOUS STAGES OF TREATMENT BY LIME-SODA SOFTENING FOLLOWED BY HOT PHOSPHATE SOFTENING
(Parts per million, except pH)

	RAW WATER	AFTER LIME-SODA SOFTENING	AFTER HOT PHOSPHATE SOFTENING	FEEDWATER (INCLUDING CONDENSATE)[x]	BOILER WATER
Turbidity	55	5	0	0	0
Total Hardness as $CaCO_3$	160	15	0	0	0
Alkalinity as $CaCO_3$	116	78	72	34	352
pH	7.4	9.7	9.9	8.9	11.6
Sulphates as Na_2SO_4	89	106	95	110	2400
Chlorides as NaCl	94	110	103	86	900
Phosphate as PO_4	—	—	3.9	3.0	62
Total Solids	344	309	286	230	3711

[x] pH corrected by acid treatment.

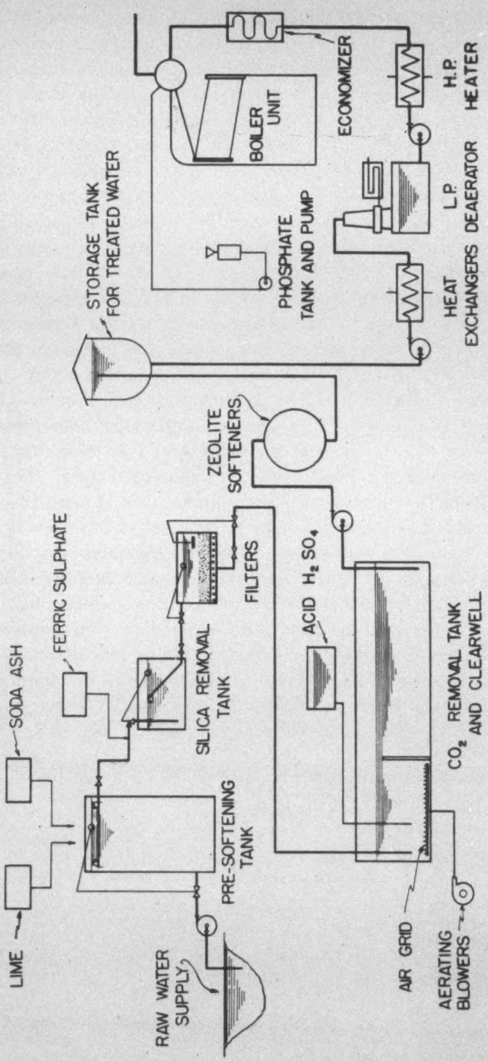

LIME
SODA ASH
FERRIC SULPHATE
RAW WATER SUPPLY
PRE-SOFTENING TANK
SILICA REMOVAL TANK
FILTERS
ACID H_2SO_4
AIR GRID
AERATING BLOWERS
CO_2 REMOVAL TANK AND CLEARWELL
ZEOLITE SOFTENERS
STORAGE TANK FOR TREATED WATER
PHOSPHATE TANK AND PUMP
HEAT EXCHANGERS
L.P. DEAERATOR
BOILER UNIT
ECONOMIZER
H.P. HEATER

FIGURE 8

A second illustration of combination treatment is given in the flow diagram shown in Figure 8. This system consists of coagulation, settling and partial softening in the primary tanks followed by further softening and silica removal in secondary tanks operated on the fill-and-draw principle. The softened and clarified water from these tanks is discharged through wooden gravity filters into a clear-water well where the water is treated with sulphuric acid and aerated. This is done to reduce the pH value of the water and remove the excess CO_2 produced by the acid treatment. The acid-treated water is then pumped to zeolite softeners which are followed by final treatment by means of phosphates, caustic soda, sulphites and sulphates. The system described is for the preparation of water used in high-pressure boilers where the make-up is high and particularly severe raw water conditions are encountered. Characteristic results produced by this plant are shown in Table 2.

TABLE 2—COMPOSITION OF WATER AT VARIOUS STAGES OF TTREATMENT BY COLD LIME SOFTENING, SILICA REMOVAL, AND ZEOLITE SOFTENING
(Parts per million, except pH)

	RAW WATER	AFTER COLD LIME SOFTENING	AFTER SILICA REMOVAL AND FILTRATION	AFTER ACID TREATMENT AND AERATION	AFTER ZEOLITE SOFTENING	BOILER WATER
Turbidity	300	50	0.2	0	0	25
Total Hardness as $CaCO_3$	168	96	76	74	1	0
Alkalinity as $CaCO_3$	140	52	27	17	16	282
Sulphates as Na_2SO_4	44	44	59	78	78	740
Chlorides as NaCl	46	46	60	60	60	492
Phosphate as PO_4	—	—	—	—	—	90
Silica as SiO_2	6.7	6.5	3.2	3.2	3.2	37
pH	8.1	10.6	9.9	8.1	7.7	—
Total Solids	243	—	157	—	187	1794

Water Purification by Ion Exchanging Materials. Possibly the most interesting development in water conditioning that has occurred in many years is the availabilty and use of zeolite materials of non-siliceous types. True zeolites will exchange a variety of positive ions such as sodium, potassium and other alkaline metals; ammonium, iron, calcium and magnesium and other alkaline earths. Since it is generally desirable and, in fact often necessary to remove other dissolved ions from water in order to make it suitable for industrial purposes, there has been considerable speculation and study as to the possibility of exchange of negative as well as positive ions, and the exchange of hydrogen ions. The double silicate zeolites are not useful for these purposes, either because the reactions in question do not occur, or because the mineral would be disintegrated by solutions involved, such as alkalis or acids.

Investigations in this field have led to the development of several specific types of materials that are coming into use for water treatment. These may be classified generally as carbonaceous zeolites and resinous zeolites. The carbonaceous zeolites may be prepared by treating various carbonaceous substances such as bituminous coal or lignite with sulphuric acid or other dehydrating agents. Patents have been granted covering the use of a large number of other organic materials. The product so prepared may be stabilized in several ways. The finished material made in this way resembles anthracite coal and possesses zeolitic properties. It may be used either in an acid or an alkaline cycle. The chemical reactions that take place with this material are shown in Table 3. Many softening plants employing this type of material have been installed within the past few years and it is predicted that such non-siliceous zeolites will be widely adopted for various applications in the treatment of industrial water supplies.

TABLE 3—REACTIONS OF CARBONACEOUS ZEOLITES

Softening, Sodium Cycle

$$\text{Ca \& Mg Salts} + Na_2Z = \text{Ca \& Mg Z} + \text{Na Salts}$$

Regeneration, Sodium Cycle

$$\text{Ca \& Mg Z} + 2\,NaCl = Na_2Z + \text{Ca \& Mg Chlorides}$$

Softening, Hydrogen Cycle

$$\left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}(HCO_3)_2 + H_2Z = \left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}Z + 2\,H_2CO_3$$

$$\left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}SO_4 + H_2Z = \left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}Z + H_2SO_4$$

$$\left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}Cl_2 + H_2Z = \left.\begin{matrix}Ca\\Mg\\Na\end{matrix}\right\}Z + 2\,HCl$$

Regeneration, Hydrogen Cycle

$$\left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}Z + H_2SO_4 = H_2Z + \left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}SO_4$$

TABLE 4—REACTION OF SYNTHETIC RESIN ION EXCHANGE MATERIALS
(Where R represents the resin)

Removal of Acid Radicles

$$R.OH + HCl = R.Cl + H_2O$$

$$R.OH + H_2SO_4 = R.SO_4 + H_2O$$

Regeneration With Alkali

$$R.Cl + NaOH = R.OH + NaCl \text{ waste solution}$$

$$R.SO_4 + 2NaOH = R.OH + Na_2SO_4 \text{ waste solution}$$

An example of the so-called resinous zeolites is the series of resins made by polymerizing compounds of various aldehydes and various aromatic amines, such as formaldehyde and aniline. Like the base-exchanging silicates and the carbonaceous zeolites, these substances will absorb various solutes and at the same time release other solutes with which they have been treated, thus effecting exchange of one compound in solution for another. However, unlike the previously described zeolitic substances, they may be regenerated with alkaline solutions to form a medium that exchanges hydroxol ions for other negative ions. Table 4 shows the reactions that take place when water that has been treated by carbonaceous zeolites in the hydrogen cycle are passed through the hydroxide form of the resinous zeolite. By taking advantage of the properties of these two zeolitic materials it is possible to produce a water from which essentially all dissolved solids with the exception of alumina, silica, and possibly the less commonly occurring elements are removed. Theoretically, a treatment plant employing these two types of zeolites in series is capable of delivering a water closely approximating that obtainable from evaporators or other distilling apparatus. At the present time, extensive experiments are being carried out by a number of investigators for the purpose of securing data for the construction of large plants. The treatment of boiler feedwater by these materials will permit the preparation of water for very-high-pressure boilers that must be operated at high ratings and with a high percentage of make-up, which ordinarily could not be done without the use of distilling apparatus. An experimental plant involving this principle of treatment and also the treatment of the water for removal of silica and color is shown diagrammatically in Figure 9. These studies are being undertaken to determine the adequacy of the combined system to prepare the feedwater for a proposed large boiler installation where the boilers will be operated at 1200 to 1400 pounds pressure and the make-up will be practically 100 per cent.

Purification of Boiler Feedwater. The various treating and softening processes described earlier are all applicable, and many of them are being widely used, for the preparation of water for boiler feedwater purposes. The severe specifications imposed on water for this purpose may make it necessary to provide special forms of treatment. In some cases it has been imperative to reduce the silica content of the water to the lowest possible point. Under certain boiler operating conditions relatively small amounts of silica present in the boiler water will deposit silica compounds forming dense, hard scale which is not controllable, within the boilers, by methods so far available. Much

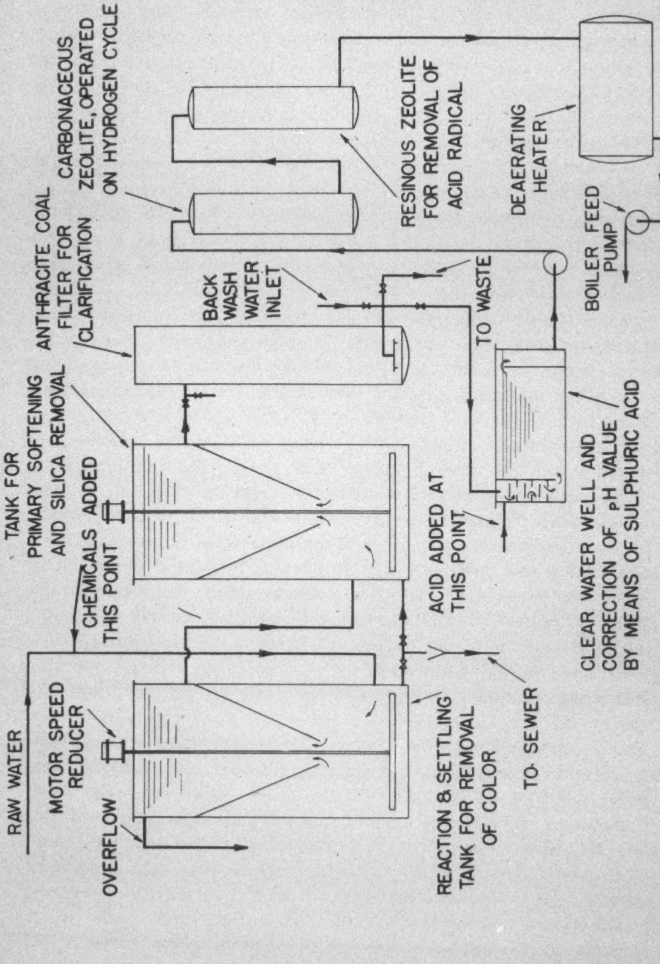

RAW WATER
MOTOR SPEED REDUCER
OVERFLOW
REACTION & SETTLING TANK FOR REMOVAL OF COLOR
TO SEWER
CHEMICALS ADDED THIS POINT
TANK FOR PRIMARY SOFTENING AND SILICA REMOVAL
ACID ADDED AT THIS POINT
CLEAR WATER WELL AND CORRECTION OF pH VALUE BY MEANS OF SULPHURIC ACID
ANTHRACITE COAL FILTER FOR CLARIFICATION
BACK WASH WATER INLET
TO WASTE
BOILER FEED PUMP
CARBONACEOUS ZEOLITE, OPERATED ON HYDROGEN CYCLE
RESINOUS ZEOLITE FOR REMOVAL OF ACID RADICAL
DEAERATING HEATER

FIGURE 9.

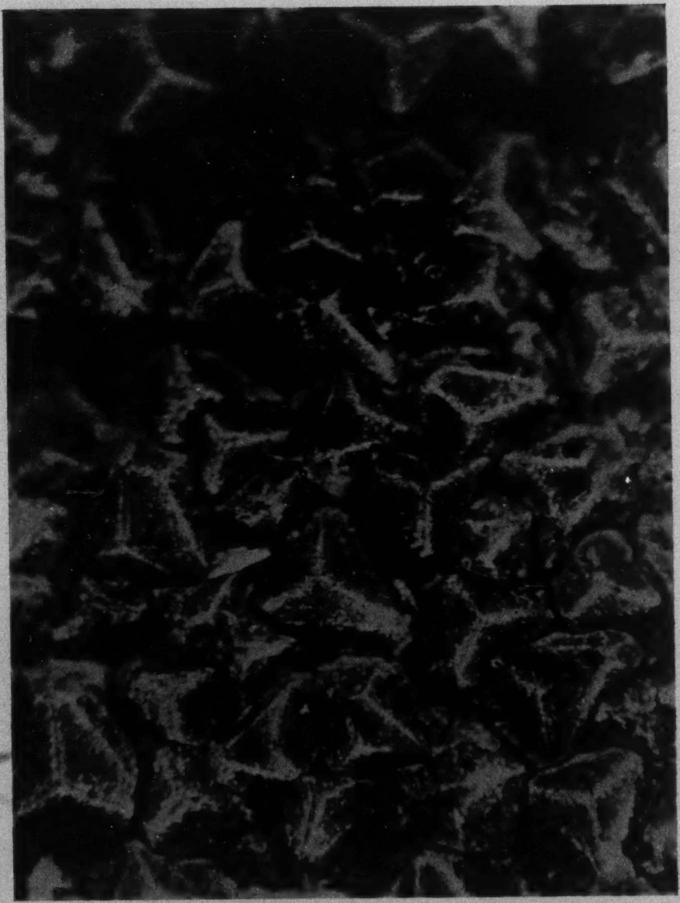


FIG. 10—PHOTOMICROGRAPH OF A THIN SECTION OF ANALCITE BOILER SCALE.

is still to be learned concerning the nature and deposition of many of these complex silicates. A photomicrograph of a thin section of a sample of this scale is shown in Figure 10. These products are known as analcite and are silicates of the zeolite group possessing many interesting properties.

Time does not permit a full discussion of these compounds and the causes of their deposition on the heating surfaces of high pressure boilers. From a practical standpoint, however, it is an established fact that the most effective method of controlling such scales or eliminating them from boilers is to reduce the silica content of the boiler feedwater to the lowest possible point. Extensive studies have been carried out to develop processes for silica removal and several large plants have been constructed for this purpose and are now in practical operation. A number of chemical processes have been developed to remove silica from water, but in the writer's experience the most effective means of reducing the silica is by means of iron salts, especially ferric sulphate. The removal, however, must be effected at a pH range of 8.5 to 9.0 or higher. By properly designing the treating plant silica can be reduced to less than 3 p.p.m. The quantity of coagulant required is relatively high and depends on the concentration of silica in the water and presence of other constituents dissolved in the supply. This form of treatment is of growing importance because of the marked trend toward the installation of high-pressure boilers. This trend is illustrated in the diagrams shown in Figures 11 and 12. The latter chart

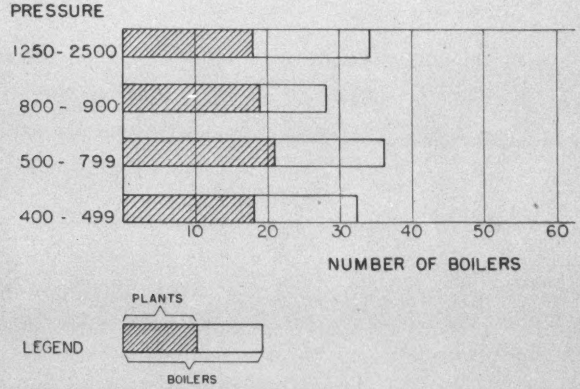


Fig. 11—Number of New Boilers Installed in Central Stations Between January 1936 and September 1937—130 Boilers in 76 Plants.

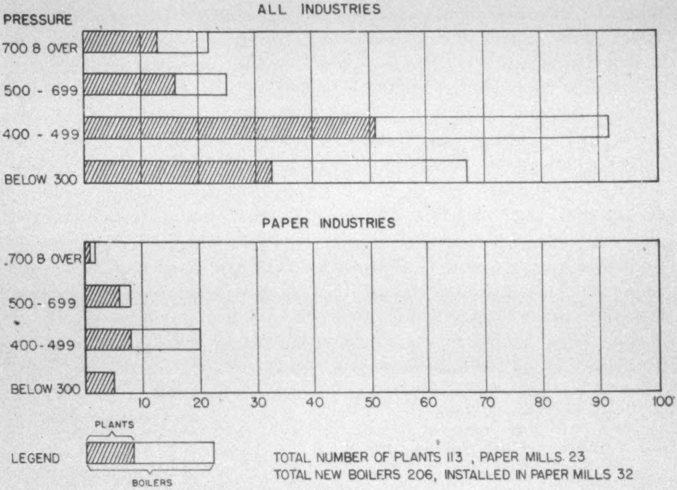
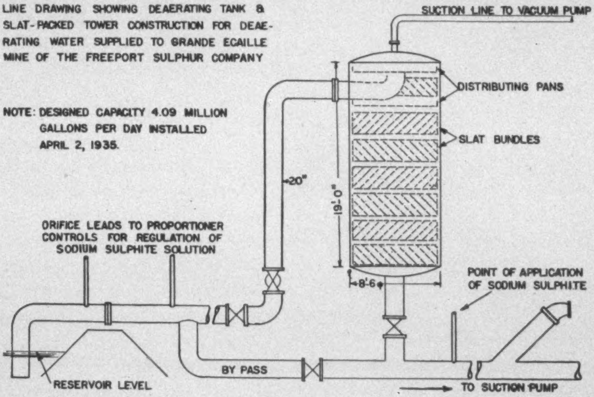


Fig. 12—Number of New Boilers Installed in Industrial Plants Between January 1936 and September 1937.

is of interest because it shows the more recent installation of high-pressure boilers in the paper industry, which is a large consumer of process water that frequently must meet rigid specifications.

Water Conditioning and Its Influence on Corrosion. The corrosion of engineering materials is and always has been a problem of major importance to industries. The water works profession has been highly successful in developing methods for protecting large distribution systems, based largely on correcting aggressive properties of the water or so conditioning the supply as to lay down a protective scale in the pipe. These methods have been used by industries, but are not always adaptable. Under conditions in which the type of material manufactured requires water of extreme purity, destruction of equipment as well as contamination of the water supply may be limited by the use of corrosion-resisting materials throughout the water treating plant and distribution systems. Where such engineering design can be justified, plants of this type should be installed. As a specific illustration, the requirements in the textile industry, manufacture of photographic materials, various high-grade papers, rayon, and other establishments demand such a high purity of water that costly materials may be justified. In less severe cases, however, where the quantity of water demanded requires a relatively large plant and distribution system, the selection of materials entering into construction is limited to the more common and less expensive materials.

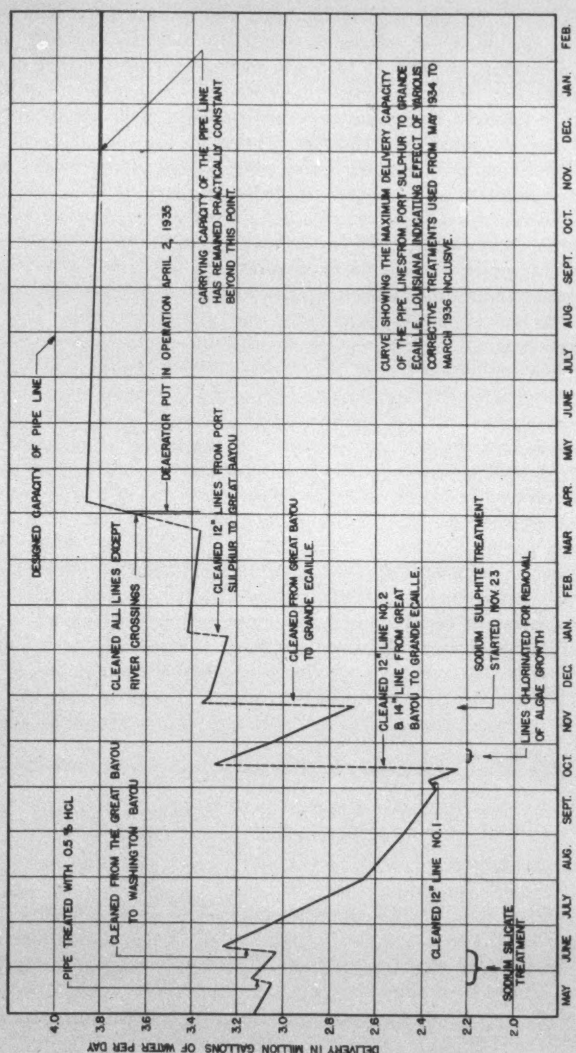
In the treatment of water for boilerfeed uses, complete deaeration of the supply by adequately designed equipment and the proper control of pH values of the treated water will ordinarily be satisfactory as corrosion-control measures. However, for systems in which large quantities of water are used for process purposes, other means of control must be resorted to. The use of coated, cement-lined, or transite pipe may effect the desired results for the control of corrosion. A further control measure is afforded by the removal of non-condensible gases from the water by means of vacuum deaerators. Two plants of this type have been recently designed and put in operation by the author. The schematic arrangement of one of these plants is shown in Figure 13. This treatment was inaugurated to correct the active corrosive property of the water, which had caused a marked reduction in the carrying capacity of a welded-steel pipe line that conveyed the process water about ten miles. The carrying capacity is shown in the chart of Figure 14. The efficiency of the system in reducing corrosion is shown in the carrying capacity of the pipe line before and after the installation of the deaerator. The cost of installation of equipment of this kind will vary with local conditions. A deaerator of this design can be installed for a cost of about $3000 per million gallons of water


LINE DRAWING SHOWING DEAERATING TANK & SLAT-PACKED TOWER CONSTRUCTION FOR DEAERATING WATER SUPPLIED TO GRANDE ECAILLE MINE OF THE FREEPORT SULPHUR COMPANY

NOTE: DESIGNED CAPACITY 4.09 MILLION GALLONS PER DAY INSTALLED APRIL 2, 1935.

SUCTION LINE TO VACUUM PUMP
DISTRIBUTING PANS
SLAT BUNDLES
20"
19'-0"
8'-6"
ORIFICE LEADS TO PROPORTIONER CONTROLS FOR REGULATION OF SODIUM SULPHITE SOLUTION
POINT OF APPLICATION OF SODIUM SULPHITE
BY PASS
RESERVOIR LEVEL
TO SUCTION PUMP

FIGURE 13.



CURVE SHOWING THE MAXIMUM DELIVERY CAPACITY OF THE PIPE LINES FROM PORT SULPHUR TO GRANDE ECAILLE, LOUISIANA INDICATING EFFECT OF VARIOUS CORRECTIVE TREATMENTS USED FROM MAY 1934 TO MARCH 1936 INCLUSIVE.

FIGURE 14.

treated daily. In the plant in question the deaerator is capable of reducing the dissolved oxygen to about 0.1 milliliter per liter at a vacuum of approximately 28 inches of mercury. This, however, is not sufficiently low to assure complete corrosion control, and the residual oxygen is removed by means of sodium sulphite with the occasional use of copper sulphate as a catalyst. This plant has been in successful operation for more than three years. The second plant was designed for the protection of a 35-mile welded-steel pipe line, but this unit has as yet not been in service for a sufficiently long time to provide figures on the pipe-line performance before and after installation of the deaerator. It is the author's opinion that this form of treatment has a wide application, and it is expected that further developments along this line will be forthcoming in the immediate future.

Conclusions. It has been impossible for the author to present an extensive discussion of all the various problems encountered in the treatment of industrial water supplies, and all that can be done in the presentation of the subject within the limited space available is to bring before this Association some of the major aspects encountered in problems of this kind. It is obvious that water conditioning for the uses in question varies widely in some respects from similar requirements in the field of municipal water treatment. The paper has been presented with the hope that it will focus the attention of water works engineers on these problems, so that they may have a somewhat better understanding of the industrial consumers' requirements, which will thereby result in a more comprehensive and mutual understanding between the groups in these allied fields of endeavor.

REMOVAL OF IRON AND HARDNESS FROM WATER

BY DANIEL J. SAUNDERS*

[*Read September 16, 1938.*]

This paper describes some of the difficulties experienced in industry and in the home due to the presence of iron and hardness in water supplies and outlines methods that can be employed to over-
When iron is present in a water supply in an amount greater than 0.3 p.p.m., it causes unsightly yellowish or black stains on bathroom
come such difficulties, under varying sets of conditions.
fixtures, gives a metallic taste to drinking water, reacts with other reagents used in dye houses, laundries, paper mills and tanneries where, for example, it combines with tannin in leather and forms black iron tannate; and deposits in municipal distribution systems, where it not only increases the friction through the mains and raises pumping costs, but where at sudden high rates of flow deposits of iron rust are loosened and delivered to the users. Further, the growth of iron bacteria, such as *Crenothrix,* is also promoted by the presence of iron.

Factors Influencing Iron Removal

The type of treatment plant required to remove iron is determined by a number of factors, such as character of the water (especially the factors interfering with oxidation reactions), engineering conditions and the purpose for which the water is to be used.

In general, iron and also manganese can be removed from well waters by two methods:

(1) Oxidation to the insoluble higher oxides and hydrates followed by filtration.

(2) Removal by base exchange, by employing correctly selected base-exchange zeolites.

However, all waters and particularly surface supplies, do not respond readily to oxidation reactions. As just mentioned, there are interfering factors to be given consideration.

Free Carbon Dioxide. High amounts of free CO_2 or any acid will interfere with the oxidation reactions going to completion. Therefore, in such cases thorough aeration, or addition of alkalis, or both, are necessary. The addition of only 0.14 p.p.m. of oxygen for each part per million or iron is theoretically required in the normal oxidation reaction. This quantity is insufficient when free CO_2 or any acid is present.

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*Manager of Industrial Sales, The Permutit Company, New York, N. Y.

Low Total Solids. With waters of this type, even though a thorough removal of the carbon dioxide is effected by efficient aeration, it is usually necessary to supplement that step in the treatment by additional steps that will be described later.

Organic Matter. Iron or manganese present in organic combinations is not removed by simple aeration and filtration. Coagulants fed into floc-forming agitating-devices to accelerate floc formation and sedimentation tanks or basins must precede the filters.

Excessive Aeration. This has been known to interfere with the complete removal of iron and especially manganese. In such cases, restricting the aeration, i.e., limiting the absorption of the oxygen to a fraction of saturation, gives better results.

TYPES OF PLANTS

Waters Low in CO_2 and Relatively Low in Iron Responding Readily to Oxidation. A small amount of air can be introduced by sniffing air into the suction side of the well pump for oxidation purposes. The well pump can then pump the oxidized water directly through either a single pressure-filter, or to avoid frequent backwashings through a coarse pressure-filter followed by a fine pressure-filter to service and use, thus making repumping unnecessary.

However, where preferred, gravity filters can be employed. Air-

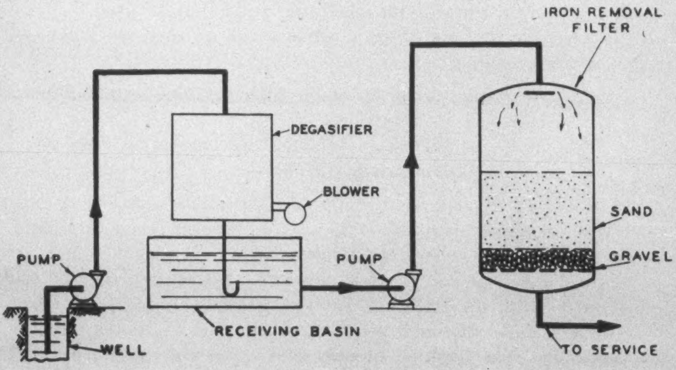

FIG. 1—DEGASIFIER AND IRON-REMOVAL FILTER.

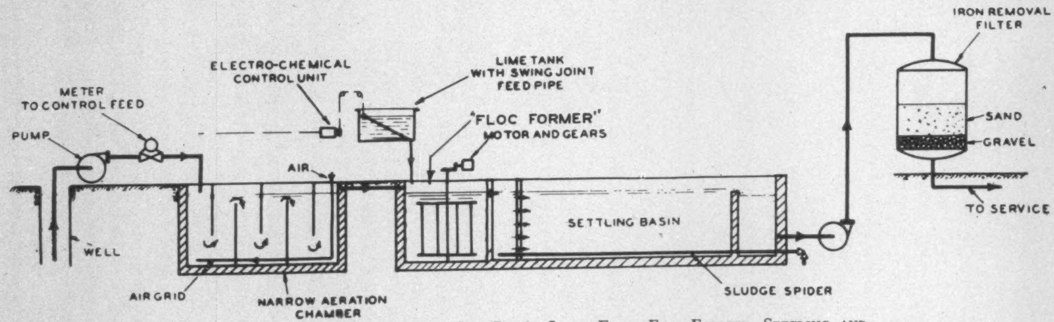
PUMP
METER
TO CONTROL FEED
ELECTRO-CHEMICAL
CONTROL UNIT
LIME TANK
WITH SWING JOINT
FEED PIPE
"FLOC FORMER"
MOTOR AND GEARS
AIR
WELL
SETTLING BASIN
IRON REMOVAL
FILTER
SAND
GRAVEL
TO SERVICE
AIR GRID
NARROW AERATION
CHAMBER
SLUDGE SPIDER

FIG. 2—COMBINATION AERATOR (AIR GRID), LIME FEED, FLOC-FORMER, SETTLING AND IRON-REMOVAL FILTER.

part per million or iron is theoretically required in the normal oxidation reaction. This quantity is insufficient when free CO_2 or any acid is present.

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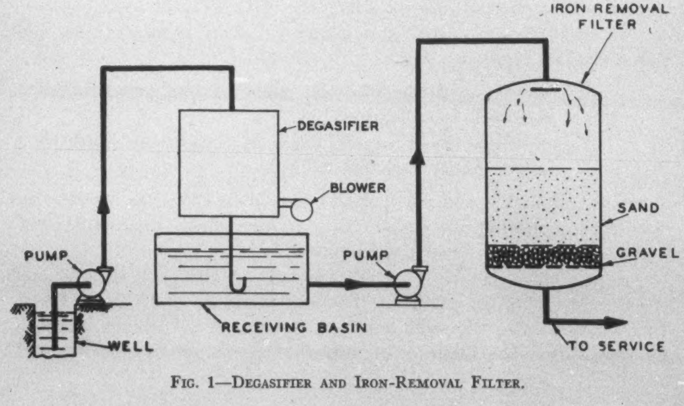


FIG. 1—DEGASIFIER AND IRON-REMOVAL FILTER.

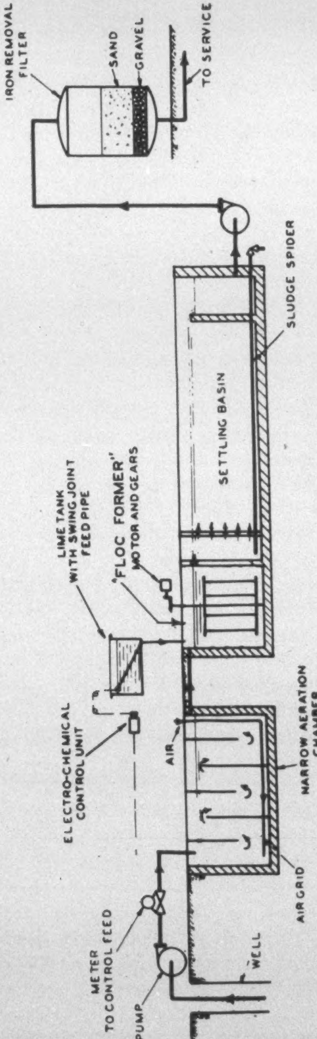

IRON REMOVAL FILTER
SAND
GRAVEL
TO SERVICE
SLUDGE SPIDER
SETTLING BASIN
LIME TANK WITH SWING JOINT FEED PIPE
"FLOC FORMER" MOTOR AND GEARS
ELECTRO-CHEMICAL CONTROL UNIT
AIR
NARROW AERATION CHAMBER
AIR GRID
METER TO CONTROL FEED
PUMP
WELL

FIG. 2—COMBINATION AERATOR (AIR GRID), LIME FEED, FLOC-FORMER, SETTLING AND IRON-REMOVAL FILTER.

wash systems should be employed where their use is deemed advisable.

Waters High in CO_2 Requiring CO_2 Removal By Alkali Feed or Efficient Aeration Before Final Filtration. In this case, the arrangement just described can be employed provided an alkali feed is installed to neutralize the CO_2. However, as air is free, if the quantity of water being pumped is appreciable, an efficient type of aerator should be installed, preferably either a coke tray type or a degasifier bubbling type to insure exposing the water to the air in thin films or drops so that each particle of water comes into contact with air low in CO_2. However, should the iron present in the raw water be very high a sedimentation tank or basin may be required. See Figure 1.

Waters of Low pH Value that do not Respond Readily to Oxidation. In such cases, following aeration, lime or soda ash is fed by means of a proportionatng chemical feed to a sedimentation tank or basin, equipped with floc formers for agitating purposes. See Figure 2.

Lime is employed for larger plants; soda ash for smaller plants. Lime gives better results because it also has a coagluating effect. However, it also increases the hardness and as this is objectionable in many cases, soda ash is employed. The settled water is then pumped through filter equipment either to the mains directly or to storage and the mains.

Waters Containing Iron in Organic Combinations. The treatment suited to any given case of this kind will depend upon the type of organic compound present. The best treatment must be determined by experiments in the field and the laboratory. Further, the treating plant should be designed so that the pH values may be altered at will and also so that different coagulants may be added as required.

Obviously, this will mean equipment for feeding various chemicals, sedimentation, possibly double sedimentation as in the case of Elizabeth City, N. C., and filtration, plus chlorination.

Waters of Low Iron Content (below 1.0 p.p.m.) Where Reduction in Iron Content Should be Below 0.1 p.p.m. Manganese zeolite filters are most effective in the removal of iron where practically complete removal is desired for industrial purposes. See Figure 3. Manganese zeolite consists of sodium zeolite treated by manganous chloride and oxidized by sodium or potassium permanganate. The manganese zeolite proper acts as an active carrier and catalytic reagent. The oxides themselves do the work of iron removal. These oxides give up oxygen to the water for the necessary oxidation reactions. They are re-oxidized by passing permanganate solution through the bed. Approximately 0.01 lb. of permanganate per thousand

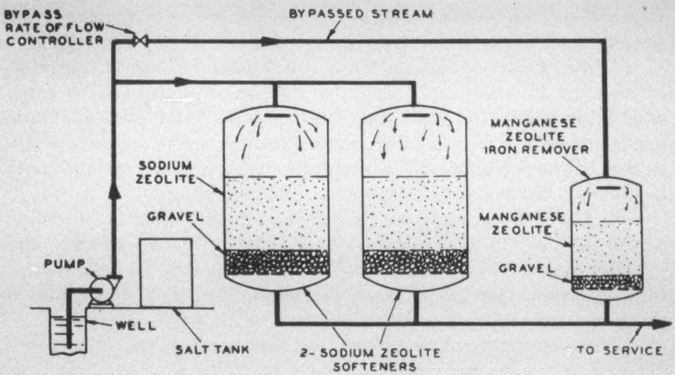

BYPASS
RATE OF FLOW
CONTROLLER
BYPASSED STREAM
SODIUM
ZEOLITE
GRAVEL
MANGANESE
ZEOLITE
IRON REMOVER
MANGANESE
ZEOLITE
GRAVEL
PUMP
WELL
SALT TANK
2- SODIUM ZEOLITE
SOFTENERS
TO SERVICE

FIG. 3—COMBINATION ZEOLITE SOFTENER AND MANGANESE IRON-REMOVER ON BYPASSED STREAM TO GIVE FINAL EFFLUENT THAT IS IRON-FREE AND CONTAINS 4-5 GRAINS PER GALLON OF HARDNESS.

gallons of water is required for the average water. These filters are backwashed daily but are usually regenerated weekly.

Sodium zeolite of the natural type, provided it has been correctly processed, or Zeo-Karb material, a carbonaceous zeolite, may be economically employed to remove iron and manganese by base exchange, at the same time that the zeolite is softening the water. When these types of zeolites are employed for iron and hardness removal by base exchange, the iron must be maintained in the ferrous form. Therefore, well waters cannot be exposed to air before the zeolite treatment. The regeneration of units of this type is accomplished by the usual sodium chloride regeneration.

WATER SOFTENING

There are five methods of water softening in general use. These are:

(1) Zeolite Process—Sodium Cycle.
(2) Zeolite Process—Hydrogen Cycle.
(3) Cold Lime-Soda Process.
(4) Combination Lime-Zeolite Process.
(5) Hot Process.

Processes No. 1, 2 and 4 will reduce the hardness of the water to practically zero. Process No. 3, depending on the way it is carried out and also the composition of the raw water, will reduce the hardness from 3 to 5 grains per gallon. Process No. 5 will reduce the hardness to some figure below 1½ grains per gallon, depending upon the character of the water, the chemicals employed, and other factors.

Zeolite Process—Sodium Cycle. With this method the hardness is removed by base exchange; the calcium and magnesium being retained by the zeolite while the corresponding sodium salts are found in the effluent. After the rated capacity of the zeolite to soften water to zero hardness has been exhausted, the softening capacity is restored by treating the zeolite with a solution of common salt.

As this salt solution comes in contact with the zeolite, the calcium and magnesium are removed in the form of the soluble chlorides, and its original sodium content is restored. After flushing the chlorides of calcium and magnesium, plus excess salt, to the drain, the zeolite is ready to soften a further equal quantity of the hard water.

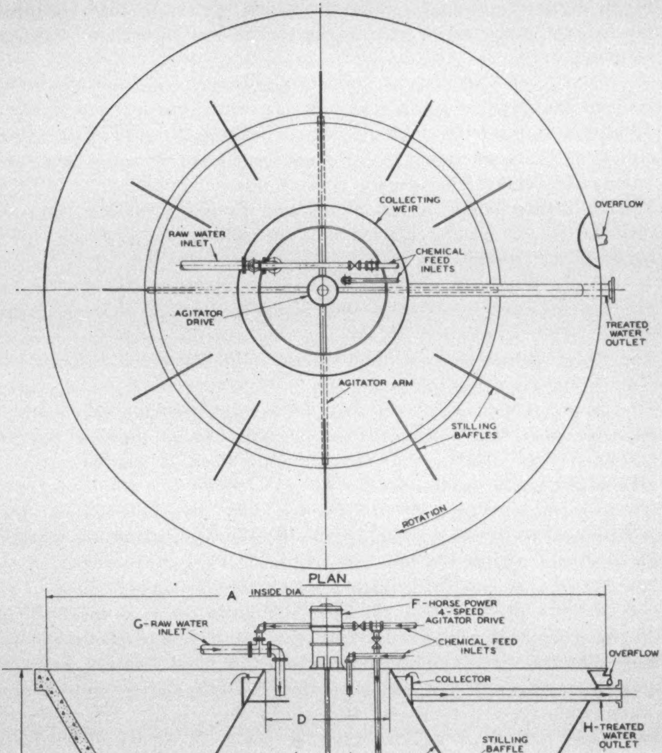
These alternate softening runs and regenerations can be repeated indefinitely, as the wear and tear on a correctly-processed zeolite is negligible. Therefore, the annual cost of replacing this zeolite is correspondingly low. The effluent from a zeolite water-softening plant is practically zero in hardness. As zero hardness water is either a requirement or at least desirable for most industrial processes, all of the water used in an industrial plant is usually passed through the zeolite plant. In the case of municipal zeolite plants, a zero-hardness water is not required. Therefore, in such cases, enough hard water is bypassed and mixed with the zeolite-softened water to yield a mixed effluent of the desired degree of hardness.

Zeolite water-softeners are available to operate automatically through all cycles of operation by a combination of a motor-driven multiport valve with electrical controls. Automatically, the equipment is cut out of service, backwashed, brined, rinsed and returned to service. About 90% of the more recent municipal zeolite water-softening plants are of the automatic type.

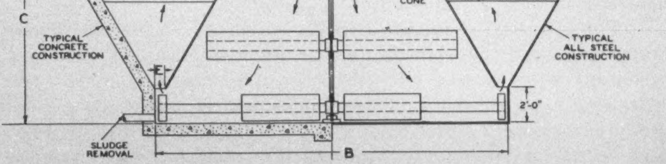
Zeolite Process—Hydrogen Cycle. In this process of water softening, a carbonaceous type of zeolite, known as Zeo-Karb, is employed. It is of especial value in softening waters of a high bicarbonate content, as the bicarbonates of sodium, calcium, or magnesium are replaced by carbon dioxide and water; the base being retained by the zeolite.

The carbon dioxide may then be removed by passing the softened water through a degasifier bubbling-type of aerator. This process, therefore, in a very simple manner practically completely removes the bicarbonates.

At the end of the softening run, the Zeo-Karb is regenerated by treating it with a dilute solution of sulphuric acid. This restores the


COLLECTING WEIR
OVERFLOW
RAW WATER INLET
CHEMICAL FEED INLETS
AGITATOR DRIVE
TREATED WATER OUTLET
AGITATOR ARM
STILLING BAFFLES
ROTATION

PLAN


A
INSIDE DIA.
F-HORSE POWER
4-SPEED
AGITATOR DRIVE
G-RAW WATER
INLET
CHEMICAL FEED
INLETS
OVERFLOW
COLLECTOR
D
H-TREATED
WATER
OUTLET
STILLING
BAFFLE
CONE
C
TYPICAL
CONCRETE
CONSTRUCTION
TYPICAL
ALL STEEL
CONSTRUCTION
E
2'-0"
SLUDGE
REMOVAL
B

SECTION

FIG. 4—SPAULDING PRECIPITATOR.

hydrogen content of the zeolite and simultaneously removes the bases in the form of sulphates. These, plus the excess of acid, are then flushed out to the drain, after which the zeolite is ready for the next softening cycle.

Cold Lime-Soda Process. In this process, as carried out in the conventional type of equipment, the raw water is treated with regulated dosages of lime and soda ash. The bulk of the hardness precipitated by these chemicals, is then settled out in a settling tank having a detention period of at least 4 hours.

It is then either recarbonated and filtered or filtered and recarbonated. As usually carried out, the effluent so produced has a hardness of 5 grains per gallon.

In the relatively newer Spaulding Precipitator (See Figure 4), the treated water is brought into intimate contact with suspended sludge. This suspended sludge acts to prohibit supersaturations. Therefore, the net result is that a more stable effluent is produced in a much shorter period of time.

In practice, it has been found that the Spaulding Precipitator requires only a one-hour detention period and that the reduction of hardness is so complete that recarbonation is either carried out to a very slight extent or eliminated.

Combination Lime-Zeolite Process. In the combination lime-zeolite process of water softening, the bicarbonate hardness is reduced by treatment with lime. The lime-treated water is then recarbonated, filtered and then passed through zeolite water-softeners.

The net effect is that the lime treatment removes the bulk of the bicarbonate hardness and the subsequent zeolite treatment removes the non-carbonate hardness plus any residual bicarbonate hardness. In many cases, it has been found economical to employ this combination type of treatment because of the savings effected in the lower cost for salt as against soda ash per 1,000 grains of hardness removed.

For industrial processes or boiler water, all of the lime-treated water is passed through the zeolite water-softeners. Incidentally, when *any* water is used for boiler feed, it is important to give consideration to supplementary treatment so that the final feedwater will conform to modern power plant practice, as prescribed by the American Society of Mechanical Engineers. For municipal water supplies, only the requisite portion of lime-treated water required to produce a 4- to 5-grain per gallon hardness in the mixed effluent is passed through the zeolite water-softening equipment.

Hot Lime-Soda Process. The hot lime-soda process of water softening is carried out by adding carefully-regulated dosages of lime, soda ash and if necessary other chemicals to the raw water, after heating it to a temperature at or near the boiling point. Since the high temperatures employed speed up the chemical reactions, a detention or settling period of only one hour is required.

The settled water is then filtered through filter beds of nonsiliceous material. Depending on the excesses of chemicals used, the hardness of the effluent varies from as low as 1½ grains per gallon down to a fraction of a grain. As this process must be carried out hot, its application is obviously practically limited to the production of boiler-feed waters.

Discussion

Horace L. Clark.* At Sanford, Maine, we installed a zeolite plant last year for the purpose of removing iron from the water. The iron content in the water from the well supply was running from 1.5 to 1.8 p.p.m., and we have been treating the water in three units and reducing the iron content to 0.1 and 0.2 p.p.m. We are using the sodium zeolite process. Treatment reduces the water to zero hardness. We mix the treated water with water from the springs, which give us about a third of our supply. Up to the present time we have been very well satisfied with the results that have been obtained. The capacity of the plant is about 750 g.p.m., and the cost about $10,000, including the salt storage bin and mixer to make the salt brine. We pump on an average between six and seven hundred thousand gallons per day, and the cost of treatment is about $10 per million gallons. We thought that the saving in first cost over the method of removing iron by aeration, sedimentation and filtration, justified the increased operating expense for a plant of this type.

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*Sanford, Me.

USE OF COOLING WATER IN AIR CONDITIONING

BY WALTON H. SEARS*

[*Read September 15, 1938.*]

The rapid growth of the air-conditioning industry and the fact that most air-conditioning installations require water, often in large quantities, has focused upon it the eyes of water works engineers and operators the country over. As a result, the subject has been thoroughly discussed in the trade magazines and in papers before water works associations. No paper on air conditioning has heretofore been presented to this Association, however, so the author has endeavored to compile available information in order to give a picture of conditions as they are and of what may be anticipated in the future.

What Air Conditioning Is. True air conditioning, as defined by Willis H. Carrier, pioneer in the development of the industry, should (1) control temperature; (2) control humidity; (3) supply ventilation; (4) provide a controlled circulation of properly tempered air; and (5) cleanse the air.

Relatively few installations perform all these functions and the Air Conditioning Manufacturers Association has adopted minimum requirements for a system to merit the term "air conditioning" as follows:

For summer air-conditioning at least: (1) The air must be cooled; (2) it must be dehumidified; and (3) it must be circulated.

For winter air-conditioning at least: (1) The air must be heated; (2) it must be humidified; and (3) it must be circulated.

Water Requirements for Air Conditioning. The amount of water required for winter air-conditioning is negligible. However, summer air-conditioning requires large quantities during what is usually the period of maximum demand, and it is with summer air-conditioning that the water works man is concerned.

Summer-cooling requires the constant removal of heat from the room or building cooled. It must remove all the heat absorbed from exposure to the sun, from surrounding air or from adjacent rooms or buildings; all the heat generated within the room by motors, electrical appliances, steam tables, coffee urns, etc.; all the heat radiated by human bodies; and the surplus heat contained in the air supplied for ventilation. This is accomplished by the continuous removal and cooling of the air and its reintroduction together with such fresh air as is required for ventilation.

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*Mechanical Engineer, Metropolitan District Water Supply Commission, Boston, Mass.

This cooling or removal of surplus heat from the air is accomplished by some type of cooler or refrigerating machine. Whatever the type, the heat removed from the air by the machine must in turn be carried away from the machine and wasted. This is usually done by water.

Now how much water does this require? This can be answered only in general terms. Among individual installations the amount will vary greatly. Not only does the heat that must be absorbed and wasted depend upon all the factors that have been enumerated and more, but the amount of water required will depend upon its temperature: the colder the water the less required for the removal of a given amount of heat. However, the average amounts of heat required to be removed in each of different types of air-conditioning service (i.e. residence, theatre, etc.) are known, and with such figures as a basis or starting point it is possible to estimate the average water requirements of each.

This has been done by Carrier Engineering Corporation with the results shown in Table 1.

This table requires some explanation.

Column 1—This gives the average amount of heat that must be removed per hour per person, expressed in Btu., a Btu., or British Thermal Unit, being the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Column 2—The standard unit of capacity of a refrigerating machine is the "ton of refrigeration" which is the absorption of the amount of heat required to melt one ton of ice in 24 hours. This is equivalent to 12,000 Btu. per hour. The amount of water required per ton of refrigeration while variable, depending on the machine and the water temperature, may, for estimating purposes, be assumed to average, in New England, 2 g.p.m., or 120 gal. per hour. Using this figure, the maxium demand of an installation in gallons per hour per person, given in column 2, is equal to: $\frac{\text{Btu. per person}}{\text{12,000 Btu. per ton}} \times 120$ gal. per hour $= \frac{\text{Btu. per person per hour}}{100}$.

Column 3—Hours of Operation per Season, is based upon experience.

Column 4—Gallons per Season at Maximum Demand Rate, needs no comment, it is the product of columns 2 and 3.

TABLE 1—WATER REQUIREMENTS IN GALLONS PER PERSON PER COOLING SEASON OF 120 DAYS OF VARIOUS APPLICATIONS OF AIR CONDITIONING
(Compiled by Carrier Engineering Corporation)

	B.T.U. PER HOUR	MAXIMUM DEMAND GALLONS PER HOUR	HOURS OF OPERATION PER SEASON	GALLONS PER SEASON AT MAXIMUM DEMAND RATE	LOAD FACTOR PER CENT	WATER REQUIREMENTS GALLONS PER SEASON
Residence	4,000	40	2,900	116,000	30	34,800
Train	1,400	14	1,200	16,800	50	8,400
Office	4,700	47	1,200	56,400	40	22,500
Lunch Room	1,600	16	900	14,400	50	7,200
Restaurant	2,000	20	1,200	24,000	60	14,500
Drug Store	2,000	20	1,800	36,000	60	21,500
Theatre	1,000	10	1,500	15,000	30	4,500
Department Store	1,600	16	1,200	19,200	60	11,500
Average	2,300			37,000		15,600

Column 5—Load Factor, is based upon experience and represents the ratio of the average demand throughout the season to the maximum demand.

Column 6—Water Requirements in Gallons per Season, is the product of columns 4 and 5.

These estimates are probably the best available. The method of approach is logical. They were prepared by experts and have been used by L. L. Lewis, Chief Engineer of Carrier Corporation, in many papers which he has given on this subject. It will be seen that the maximum requirements vary from 10 gal. per hour per person capacity in the case of a theatre to 47 gal. per hour for office service and the season's requirements from 4,500 to 34,800 gal. per person, averaging 15,600 gal. per person.

Now, if all this water required for air conditioning were to be taken from the public supply, used as a cooling agent and then wasted, it is evident that a material increase in the use of air conditioning would produce a very considerable increase in water consumption. For instance, if the air-conditioning capacity amounted to 50 per cent of the population—that is if there were air conditioned space sufficient to accomodate half the population at one time—the water required for air conditioning in a season of 120 days would be equivalent to $\frac{15{,}600}{365} \times \frac{1}{2} =$ over 22 g.p.d. capita of population the year round with a maximum demand of $\frac{37{,}000}{120} \times \frac{1}{2} = 154$ g.p.d. per capita.

But, it is not necessary to waste all the water. By the use of cooling towers and similar devices, the water may be cooled and 90 to 95% of it re-used, the remaining 5 to 10% being principally lost by evaporation in the process of cooling the water. These machines, however, cost money to install and to operate, and their economic feasibility is dependent upon the cost of water and of power and also upon the temperature of the water. Also, some owners prefer to pay larger annual operating charges rather than to make a larger initial investment.

At any rate, water-conserving devices are by no means used generally, though there is an increasing tendency to employ them. For the country at large, 60% of the capacity of the installations that were made in 1935 were equipped with water-saving devices. In the Boston Metropolitan area it is believed that less than 50% of the capacity is so equipped.

The effect of the use of water-saving devices upon water consumption is shown in Table 2, also compiled by Carrier Engineering Corporation.

TABLE 2—AVERAGE WATER REQUIREMENTS, GALLONS PER PERSON
(Compiled by Carrier Engineering Corporation)

	(1) IF NO EVAPORATIVE CONDENSERS OR COOLING TOWERS USED	(2) 1935 PRACTICE WHICH WAS 60% USE OF EVAPORATIVE CONDENSERS AND COOLING TOWERS	(3) IF 100% EVAPORATIVE CONDENSERS AND COOLING TOWERS USED
Per cooling season of 120 days	15,600	6,700	780
Maximum per day	300	130	15
Average per day per year of 365 days	43	18	2

In this table the first column shows the total water used per person of capacity in a 120-day season if no evaporative condensers or cooling towers are used, the figure 15,600 gal. being the average appearing for this item in Table 1; the maximum daily requirement and the use per person in 120 days averaged over the entire year, are also deduced from Table 1. The second column shows the same data provided 60% of air-conditioning capacity were equipped with water-conserving devices saving 95% of the cooling water used. The third column shows what the same requirements would be if all capacity were so equipped so that only 5% of the total cooling water would be wasted.

The possibilities in the conservation of water by the use of water-savers are strikingly shown in this table.

Water Required for Air Conditioning in a Specific Community. The accuracy of any estimate of the water required for air conditioning in any community depends upon the completeness of the data available. Given the number, capacity and type of all air-conditioning installations, the temperature of the water and data on the use of water-saving apparatus, a fairly accurate estimate can be made with the help of the equipment manufacturers. But such complete information is rarely at hand. It may be obtained, however, by the expenditure of time and money, and it may be kept up to date at little expense if suitable regulations are set up requiring the approval of air-conditioning installations by some appropriate department—water, sewer, plumbing or electrical department—and there is interdepartmental coöperation.

A rough approximation of the water used for air-conditioning may often be made from the records of the local electrical company. Many public utilities keep an accurate record of the horse power of motors connected for operating air-conditioning apparatus and sometimes other pertinent data relating thereto. In fact the public utilities have been quick to realize the field for the sale of power that air-conditioning opens up and are diligently working for its expansion and keeping rather complete records. Since roughly one horse power is required for each 5 persons of air-conditioning capacity, the total horse power devoted to air conditioning indicates the total capacity of air conditioning installed. With this figure and the averages given in Tables 1 and 2, it is possible to approximate the water requirements, at least within limits.

For instance, about a year ago it was desired to know how much draft air conditioning was making on the Boston Metropolitan Supply. No records were readily available of actual installations, but it was found that the Boston Edison Co., whose territory largely coincides with that of the Boston Metropolitan Water District, had a record of about 14,700 horse power of connected air-conditioning load, indicating, at 5 persons' capacity per horse power, about a 73,500-person capacity of air conditioning. Based on Table 2, that capacity would require a total of about 1,147 million gallons of water a year and a maximum demand of 22 m.g.d. if no water-conserving devices were used, but the Edison Company's records also showed that about 45% of the connected air-conditioning load was equipped with water savers. Allowance for this reduced the estimated water requirements to a total of 656 million gallons per year, a yearly average of 1.8 m.g.d., and a maximum demand of about 12.6 m.g.d. That was rough and ready figuring, but it was surely within the proverbial "row of sour apple trees" and certainly better than any guess. Such a method serves a useful purpose and may be sufficient, but it is, of course, of little value where there is an actual or threatened shortage of supply or inadequacy of distributional facilities or treatment works.

To forecast what the future may bring to any community in the way of increased demand caused by the introduction of air-conditioning equipment is difficult, as it involves not only consideration of the probable increase in the use of such equipment, but also prediction of the extent to which water-conserving devices may be used. The safest course is to find out the conditions as they are and keep the record up to date as time passes. In these records should be included, separately of course, those installations that obtain water from private wells, since in the event of the failure of the wells the load would descend suddenly upon the public supply. This has occurred in Atlantic City, Chicago and other places.

The Department of Commerce Investigation. The Marketing

Research Division of the Bureau of Foreign and Domestic Commerce has recently (April, 1938) published a report by O. C. Holleran,[1] entitled "Effect of City Water and Sewerage Facilities on Industrial Markets and Their Relation to the Market for Air-Conditioning Equipment, Market Research Series No. 17", giving the results of replies received from a questionnaire sent to all cities and towns of the United States having a population in excess of 20,000. This questionnaire, of which a copy is published in the report, sought information as to population served by each water system, its source, storage capacity, delivery capacity, consumption during the years 1931 to 1936, inclusive, reasons for increased consumption other than population increase, adequacy of supply and various distributing facilities to meet increased demand, the number of water-using air-conditioning installations, the volume of water used by them, water temperatures, the final disposal of cooling water, the effect of the air-conditioning demand and consumption upon the available public supply, the extent of the use of water-conserving devices and finally as to the probability of the requirement of the use of such devices in the future.

The primary object of the investigation was to supply the air-conditioning industry with authoritative data on available water supplies to be used to guide it in the direction of its sales efforts and as to the type of apparatus best adapted to each community, but the results are also of interest and value to water works engineers and operators. It is probable, indeed, that many water system heads in answering all the questions conscientiously learned things about their systems that they did not know before and, what is quite as important, found out that there are vital factors about which they had no information in their records.

The Department sent out a total of 486 questionnaires of which 434 were returned, filled out as far as possible with the data available. Of the 52 cities that were unreported, a number are parts of metropolitan districts and inseparable—the others just didn't return them.

The author of this report has said[2] "Of all the facts developed by this study, the most startling one is the apparent lack of knowledge of actual conditions within their operating zones shown by the responsible water authorities of a great many communities. In a number of schedules the authorities have specified that in their opinion water use was due to air-conditioning installation only to state later that they had no record whatsoever of the number of air-conditioning installations in their communities nor the amount of water being used by them." A scanning of the tables given in the report, particularly that table giving the answers to the questions concerning air conditioning, bears out Mr. Holleran's statement.

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[1] Chief, Industrial Marketing Unit, Marketing Research Division.

[2] "Increases in Water Demand and Their Causes" a paper by O. C. Holleran presented at the April, 1938, convention of the American Water Works Association.

Now, this lack of knowledge is something with which we should be concerned. Air-conditioning demand is seasonal in character and occurs for only about three months in this climate, but those three months coincide with the period of yearly peak demand. Hence, unless the supply and distributing facilities are known to be adequately margined, it is important to know to what extent such a potential water-hog as air conditioning is contributing or may be expected to contribute to the demand. The same is true, of course, of other large users such as industrial plants, but the seasonal character of air-conditioning makes it particularly dangerous to systems of limited capacity.

It is interesting to note what the investigation showed with respect to New England. An analysis of the returns show that 78 cities and towns in the 6 New England States received questionnaires and that 12 of these did not return them. Of the 66 schedules returned, 23, or about ⅓, did not answer the questions concerning the number of air-conditioning installations and water consumed by them. Eighteen, or 23 per cent, reported no air-conditioning installations, which is perhaps an interesting compliment to our New England climate; 14 reported the number of installations but not the water consumption and only 11, or 1 in 7 of those sent out, reported both number and water consumption.

New England probably does not offer as promising a field for air conditioning as do sections of the country with less bearable summer climate, and it seems probable that air conditioning will for a long time be less in demand than in the south and middle west. Of the 25 cities reporting air conditioning in New England, 12 are in Massachusetts, 8 in Connecticut, 3 in Rhode Island, 1 each in Maine and New Hampshire and none in Vermont. That is probably about in proportion to the population, but it is probably also true that it is about in inverse proportion to natural summer comfort.

However, the spread of air conditioning is by no means solely dependent upon the apparent need for it or upon public demand. Competition plays an important part. If one theatre, one restaurant or one department store installs air conditioning, it is not long before competitors follow suit, and this happens where the natural conditions do not require it except for relatively infrequent periods of short duration.

The Control of the Use of Water for Air Conditioning. Water supply systems fall into two general classes: (1) Those that have an ample supply with adequate distributional facilities; and (2) those that are limited, either in supply or facilities or both.

To the first of these classes increased use means added revenue without additional investment and to those of this class with an untreated gravity supply, the added revenue is so much velvet. To this class, air conditioning without the use of water-saving devices is a boon. Perhaps it would be well to add the proviso—if the sewer systems can stand the increased use of water.

To the second class, air-conditioning may be a real menace. The air-conditioning demand is only of about 3 months' duration, and investment in additional supply or for distribution or treatment facilities to be used for such a small portion of the time is a serious matter and unfair to other water users. In such cases, regulation by the requirement of the use of water-conserving devices for the larger installations is fair and desirable.

The case of water for air-conditioning is analogous to the sale of electricity where a demand charge is made based on the theory that the consumer should pay the fixed charges of the generating capacity which must be held in reserve for his use, and it seems reasonable that facilities—pumping plants, mains and treatment works—installed to care for a temporary peak, but idle or unnecessary during three-fourths of the time, should be charged, by some form of demand charge, against the users creating the peak.

In conclusion, the writer submits that it is perfectly fair and reasonable, where conditions require it, that the use of water-conserving devices be mandatory or that those creating the necessity for large investment to care for the peak created by their seasonal demands be required to pay the carrying charges thereof, but that justice also requires that the facts as to the extent of the use of water for air-conditioning be known before any such regulations are put into effect. We must not lose sight of the fact, however, that air-conditioning is in the interest of public comfort and health for which the public water supply exists.

MODERN MOTOR PUMPERS AND THEIR INFLUENCE ON WATER WORKS

BY GEORGE W. BOOTH*

[*Read September 15, 1938.*]

Water supply systems have a dual function: first to supply water for domestic and industrial purposes, and second to provide fire protection. A large majority of the water supply systems date back many years and were built at a time when the pumping capacity in the fire department was much less than at present. Though steam fire-engines were available for quite a long time past, their cost and the expense of operation were high for those days, and where possible the water system was developed to make the use of fire engines unnecessary. In these cases pressures on the system had to be high enough to permit streams being delivered direct from hydrants; where steamers were provided, their actual use was in most cases limited to one stream each, or at best to two or very occasionally three streams. This was not limited by their theoretical rating, as some were rated as high as 1250 g.p.m., but the inability to keep up steam usually prevented full operation.

With the advent, some 25 years ago, of the automobile fire-engine, or pumper, as it is now known, conditions did not change much, because of the lack of power in the gasoline motor available and the inertia in fire-department practice which, based upon steamer service, still tended to limit operation to one line from a pumper; and often this line was used with a 1-in. or 1⅛-in. nozzle resulting in a delivery of less than 300 g.p.m. per machine.

The small villages and towns made use of the less expensive commercial chasses, such as the Ford, which up to a few years ago could operate pumps of only 200- to 350-g.p.m. capacity. In the larger cities the usual capacity of pumpers was 500 to 750 g.p.m., with a few of 1000-g.p.m. capacity, principally in the downtown areas of the larger cities. A few pieces of apparatus of up to 1500-g.p.m. capacity were built, but the size of the motor necessary for this capacity resulted in a not very satisfactory piece of mobile equipment.

Development and refinement of the automobile gasoline engine, brought about by the demands of trucking and bus transportation, has resulted in a high-speed multi-cylindered engine of such efficiency that great power can be obtained without excessive weight. Engines of over 200 h.p. are readily available, and even the smaller commercial trucks are powered with motors of at least 80 h.p. This means that even the smallest village or fire district can and will install pumpers of 500-g.p.m. capacity, and equipment of up to 1500-g.p.m. capacity is being purchased by communities of all sizes. The most common size now in service in the larger towns and cities is 750 g.p.m., but the trend is toward the purchase of 1000- or 1250-g.p.m. pumpers.

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*Chief Engineer, Commitee on Fire Prevention and Engineering Standards, National Board of Fire Underwriters, New York, N. Y.

The pumper almost always carries its own hose and its cost in excess of that for an automobile hose wagon is so comparatively small that many fire companies, which were formerly equipped only with a hose wagon, are now provided with a pumper. Even though the pump may not be used in its regular response area, where the water pressure is sufficient for direct streams from hydrants, this added pumping capacity is often useful in connection with a serious fire in any part of the community. A further influence which must be considered is the ability to concentrate large pumping capacity at time of fire through the response of outside aid. This was demonstrated in the Fall River conflagration where 28 companies responded from outside cities and towns.

During the past decade the fire departments of America have had an awakening as to the value of drills and training. This development has been gradual but has progressed from this simple evolutions of laying hose and climbing ladders to the definite study of fire extinguishment. There is a progressive realization of the various ways for using water for fire extinguishment, ranging from small streams for small fires to the concentration of numbers of large streams for the serious and spreading fire. Water towers, wagon pipes or turret nozzles and large tips on portable lines are the answer to this. The commonly accepted value of 250 g.p.m. for a fire stream no longer holds. A good outside hand-line delivers 300 g.p.m. or more, and the 1½-in. and larger nozzles can be depended upon to deliver over 600 g.p.m. of water. In fact a 2-in. stream, which is not uncommon in fire service in the larger cities, may readily discharge 1000 g.p.m.

All of this is leading up to the fact that in the future we may readily expect fire engines, or pumpers, to be operated at or near their rated capacities. Some cities have standing orders that fire companies responding must make use of the extra outlets on pumpers already operating before setting their own pumper, thus providing a reserve engine capacity on the fire ground. The value of this is that hose lines are shorter, streams more effective and general operations improved. In Los Angeles, recognition of these advantages has resulted in the purchase of two fire engines of 2,000-g.p.m. capacity each.

While in the past only steamers were provided with pumps, cities are now installing pumps on ladder trucks, and it may be that advantage will be taken of the relatively low cost of the pump to make use of the power of the engine on each piece of fire apparatus, thus securing the maximum of pumping capacity for emergencies.

All of these developments have resulted in a tendency on the part of the fire departments to use more water in fighting fires and to attempt to concentrate the demand to a relatively few hydrants. Even in the smaller places there may be demanded as much as 1000 g.p.m. from individual hydrants, even though no pumper of this size is in service, since engines of this capacity may respond from outside communities. It is not likely that greater quantities per hydrant will be called for, even though pumpers of greater capacity are available, except in cities of metropolitan size, as the amount of hose and number of men will restrict the use of water.

One advantage favoring the water works is that the use of pumping engines by the fire department is so much more common than formerly that hydrant pressures at the higher and more remote points of the distribution system, while insufficient for direct streams are adequate for supply to pumpers. A residual pressure of 20 lb. per sq. in. may be relied upon as adequate for pumper supply, or even as low as 10 lb. per sq. in. for large outlets, whereas 50 lb. per sq. in. is about the minimum for direct streams.

A point of interest to water works officials is that for fires in residential areas, particularly those where the conflagration hazard is low by reason of lack of congestion and the absence of wooden shingle roofs, modern fire methods involve the reverse of those for congested areas. Instead of large quantities of water, small streams from 1½-in. hose are being used. The much greater general use of automobiles and other convenient means of transportation in recent years has developed a trend in many communities towards the construction of small individual houses at distances ranging up to 10 miles or more from the center of the city. This has produced a problem for the water works man, since if he is to attempt to furnish fire protection, the use of at least 8-in. pipe is necessary for the long dead ends usually found.

Another problem is presented by reason of the tendency to locate factories on the outskirts or even beyond the limits of the city. Cheaper land and lower taxes furnish the inducement, and again the private automobile makes transportation easy for employees, and trucks take care of the transfer of raw materials and finished products.

In the congested centers of cities and towns the influence of automobile apparatus has been mainly in the direction of greater concentration of fire apparatus for serious fires. Although the quick concentration should lessen the conflagration hazard the probability of a major catastrophe from fire will exist and there will still be need of designing and strengthening the water system to assure each and every pumper getting its full supply of water.

It goes without saying that the onus of an inadequate supply for fire fighting is not desired by any water department official. There was a time, years ago, when fire department claims that it was hampered by lack of water were rather frequent. In recent years that has not been so common, but the use of larger pumpers and the practice of operating them to near capacity may well result in the call for increased supply. A supply of 500 g.p.m. from the individual hydrant was formerly sufficient; that has now risen to 750 and in some cities to 1000 g.p.m. Whether in the future greater demands will be made is not apparent at present, although it is evident in a few of the metropolitan cities.

This increased use of water for fire fighting may necessitate larger and better designed hydrants than are now used, and will certainly render obsolete any with friction losses in branch and barrel exceeding 20 lb. per sq. in. for a 1000-g.p.m. flow. Definite strengthening of the gridiron system, to eliminate 4- and 6-in. pipe for hydrant supply in high-value areas, will be necessary. Further, in many cities there will be need of greater carrying capacity of the arterial system, to furnish that concentration of supply necessary. In many cases the best way of doing this is by providing a supply from both ends of the arterial system. Some appreciation of this has been noticed in recent years, as evidenced by the increasing use of elevated-tank storage, but it is evident that many designing engineers have not recognized that every million gallons in elevated storage, on the opposite side of the maximum demand point to that from which the supply normally comes, provides nearly 2,000 g.p.m. of fire flow for a ten-hour fire. This is at least the equivalent of an additional 12-in. supply main, and 2,000,000 gallons of storage can be considered as the equivalent to a 16-in. pipe.

In general, it is felt by the engineers of the National Board of Fire Underwriters that the problem of taking care of the present fire demands, in addition to the need for an adequate and dependable supply works and more elevated storage, can be summarized by the following recommendation:

That general improvement of the distributing system be made by eliminating dead ends; by removing 4-in pipe and by using 8-in. pipe for minor distributers where the gridiron is incomplete; by gridironing congested high-value areas largely with 12-in. mains; by so gating mains that not more than two hydrants will be affected by a shut off; and by providing hydrants of good size at a ratio of one to each 110,000 sq. ft. of occupied territory, with closer spacing up to one to each 40,000 sq. ft., in high-value sections where concentration of streams may be necessary.

ERRATUM

Calculation of Chemical Dosages Required for the Prevention of Corrosion, by Edward W. Moore. Published in Vol. 52, September, 1938, p. 311.

In the November issue of the Journal of American Water Works Association, Langelier* has published a note stating that the values of pK'_2 —pK'_s in his original paper** are in error for temperatures other than 25°C. Since Table 1, p. 312 of this JOURNAL, Vol. 52, September 1938, is based on Langelier's table, it is also in error as originally published. A corrected table is given herewith.

TABLE 1—VALUES OF THE CONSTANT K.
TEMPERATURE, DEGREES CENTIGRADE.

SOLIDS P.P.M.	0	10	20	25	50	60	70	80	90
0	11.75	11.53	11.32	11.24	10.82	10.66	10.53	10.38	10.25
20	11.84	11.62	11.41	11.33	10.91	10.75	10.62	10.47	10.34
40	11.88	11.66	11.45	11.37	10.95	10.79	10.66	10.51	10.38
80	11.92	11.70	11.49	11.41	10.99	10.83	10.70	10.55	10.42
120	11.96	11.74	11.53	11.45	11.03	10.87	10.74	10.59	10.46
200	12.01	11.79	11.58	11.50	11.08	10.92	10.79	10.64	10.51
280	12.06	11.84	11.63	11.55	11.13	10.97	10.84	10.69	10.56
400	12.11	11.89	11.68	11.60	11.18	11.02	10.89	10.74	10.61
520	12.16	11.94	11.73	11.65	11.23	11.07	10.94	10.79	10.66
680	12.21	11.99	11.78	11.70	11.28	11.12	10.99	10.84	10.71
800	12.23	12.01	11.80	11.72	11.30	11.14	11.01	10.86	10.73

*Langelier, Jour. Am. Water Works Ass'n 30, 1806 (1938).
**Langelier, Jour. Am. Water Works Ass'n 28, 1508 (1936).

PROCEEDINGS

FIFTY-SEVENTH ANNUAL CONVENTION

BOSTON, MASSACHUSETTS

September 13 to 16, 1938

The following is a synopsis of such parts of the proceedings of the Fifty-seventh Annual Convention as appear to be of value for the record.

The Fifty-seventh Annual Convention of the New England Water Works Association was held at the Hotel Statler, Boston, Mass., September 13 to 16, 1938.

TUESDAY, SEPTEMBER 13

Morning Session

The convention was called to order by President Warren J. Scott at 11 A.M.

Secretary Gifford announced the election by the Executive Committee of the following members:

Members: William H. Doggett, Massachusetts State Department of Public Health, Dedham, Mass.; Harold M. Tarr, C.E., Arlington Heights, Mass.; Louis H. Alman, Haverhill, Mass.; David R. Smith, Director of Public Works, St. John, N. B.; John E. Riordan, Filter Superintendent, Norwalk, Conn.; Joseph M. Peirce, Commissioner of Public Works, Fitchburg, Mass.; Thomas E. Kennedy, Water Construction and Maintenance, Fitchburg, Mass.; Aram H. Hatch, Chief Chemist, Balboa, C. Z.; Arthur W. Harrington, Water Distribution General Foreman, Malden, Mass.; Lorrin M. Pittendreigh, C.E., New Bedford, Mass.; Edwin L. Jette, Superintendent of Water Supply, Salisbury, Mass.

Associates: International Filter Co., New York, N. Y.; Keasbey & Mattison Co., Ambler, Pa.; Water Leak Detector Co., Columbus, O.; E. & F. King & Co., Inc., Boston, Mass.

ADMINISTRATIVE REPORTS

The Annual Reports of the Secretary, Treasurer, Editor and Finance Committee were presented (see p. 478), accepted and ordered placed on file.

The Annual Report of the Legislative Committee was read by Arthur C. King, Chairman, accepted and ordered placed on file (see p. 488).

CLOSING OF POLLS AND APPOINTMENT OF TELLERS

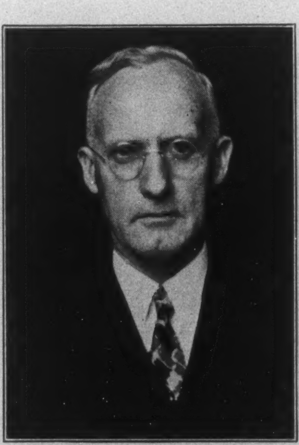
The PRESIDENT declared the polls closed and appointed three tellers to canvass the ballots, as follows: Harold L. Brigham, Chairman, Henry T. Gidley and C. P. Moat.

Luncheon Session

The Luncheon Meeting was addressed by Captain Patrick T. McQueeney, who brought the greetings of the Commonwealth of Massachusetts as the representative of His Excellency, Governor Hurley; and by His Honor, Mayor Maurice J. Tobin, who welcomed the Association on behalf of the citizens of the City of Boston.

AWARD OF THE DEXTER BRACKETT MEMORIAL MEDAL

LINN H. ENSLOW: The Committee on the Award of the Dexter Brackett Memorial Medal wishes to present as its recipient John R. Baylis, Physical Chemist, Department of Public Works, Chicago. Mr. Baylis is the author of the winning paper "Filter Bed Troubles and Their Elimination" published in the March, 1937, issue of the JOURNAL.



JOHN R. BAYLIS, Recipient of Dexter Brackett Memorial Medal, 1938

Mr. Baylis, a country boy from the deep South, was born and reared in the town of Estabutchie, Miss. He was graduated by the A. & M. College of Mississippi in 1905 and became associated with an engineering firm which in 1913 designed one of the first filter plants in the South—that of Jackson, Miss. It became Baylis' lot to "make the thing work" after it was completed. This he did so well that Jackson made him Superintendent of its Water Department in 1915. Some of his accomplishments there put the first spotlight on John Baylis and, in 1917, he was brought to the new Baltimore, Md., Filtration Plant as Chemist, again, to "make the thing work."

When Chicago decided to construct the largest and most complete experimental filtration plant ever built, anticipating the design of a plant of 550-m.g.d. capacity at a cost of approximately $20,000,000, Mr. Baylis was selected to assist in the design and then to direct the work of this experimental plant. Since 1926 he has thus served Chicago and, as the result of the graciousness of his superiors in allowing free release of information and data, Mr. Baylis through his papers and published articles has given to the water works profession a deal of information of worth.

Amongst the medalist's twelve major achievements may be cited the following: (1) Development of the now widely employed lime treatment for corrosion control; (2) The Baylis Turbidimeter for refined measure of turbidity, leading to improved filtration practice; (3) Methods of evaluating activated carbons in taste and odor removal, leading to the production of improved carbons for water purification; (4) Evaluation of filtering materials, with improved specifications resulting; (5) Adaptation of silicates in improved, if not more economical, coagulation and flocculation; (6) Continuous pH recording, and specially designed electrodes therefor; (7) Improved filter bed performance, involving procedures for measuring mud-ball accumulations, and tolerance thereof; (8) The Baylis Surface Wash System for filters, which developed from his painstaking studies of filter-bed behavior and filtering materials. And it should be noted that the Baylis Surface Wash System is now being adopted in important plants here and abroad, the largest being that of Milwaukee.

Mr. Baylis is the author of the exhaustive 392-page text, "Elimination of Taste and Odor in Water," published in 1935. In 1926 he received the James Laurie Prize of the American Society of Civil Engineers, and in 1932 the John M. Goodell Prize of the American Water Works Association.

John R. Baylis: Mr. President, Members of the New England Water Works Association. Any attempt to express my appreciation of the high honor conferred upon me by this Association would not adequately express my feelings. The things that make us most happy are the praise that we receive from the members of our profession.

These very generous remarks of Mr. Enslow also are greatly appreciated, though he has praised me too highly. Yesterday I visited the historic Lawrence Experiment Station, and how I wish I could have turned back some forty to forty-seven years ago when those great men of our profession were bringing forth a new profession, destined to play such an important part in the health and happiness of humanity. When I think of the work of these men at Lawrence, Massachusetts, and Louisville, Kentucky, prior to 1900, I realize that my own accomplishments have been quite meager compared to theirs. They developed a profession; we are trying to carry on in their footsteps.

Afternoon Session

A paper "New Butt-Welded Steel Standpipe for Scituate, Mass.," prepared by William J. Lumbert, Superintendent, Water Department, Scituate, Mass., was read by E. Sherman Chase.

A paper "Public Surface Water Supplies in Massachusetts," was read by Francis H. Kingsbury, Senior Sanitary Engineer, Massachusetts State Department of Public Health, Boston, Mass.

A paper "Ground Water in the Buried Pre-Glacial Valleys of Massachusetts," prepared by Irving B. Crosby, Consulting Geologist, Boston, Mass., was read by Secretary Gifford. Francis H. Kingsbury discussed the paper.

WEDNESDAY, SEPTEMBER 14

Morning Session

President Warren J. Scott in the chair.

William R. Conard, as Chairman, read a progress report of the Committee on Specifications for Cast Iron Pipe and a progress report of the Committee on Standardization of Pipe Flanges and Fittings.

Henry E. Halpin, as Representative of the Association, read a progress report of the Sectional Committee on Standardization of Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing.

Richard H. Ellis, as Chairman, submitted a progress report of the Committee on Collection and Tabulation of Statistical Data.

These progress reports were accepted and ordered placed on fiie.

The balance of the session was devoted to a symposium on "Cost of Water Supply in New England," with Frank A. Barbour, Consulting Engineer, Boston, in the chair. Papers were read as follows:

"Cost of Small Surface Supplies," by George A. Sampson of Weston & Sampson, Consulting Engineers, Boston, Mass.

"Cost of Ground Water Supplies," by Paul F. Howard of Whitman & Howard, Consulting Engineers, Boston, Mass.

"Cost of Distribution Systems," by William W. Brush, Editor, Water Works Engineering, New York, N. Y.

A discussion of "Relation between Unit Cost and Size of Supply," was participated in by Caleb M. Saville, Karl R. Kennison, Richard H. Ellis, Harold K. Barrows, W. C. Hawley, Stephen H. Taylor, Theodore L. Bristol, Roger W. Esty, Percy A. Shaw, E. Sherman Chase, Linn H. Enslow, Warren J. Scott, Harold L. Brigham, Elson T. Killam, and E. H. Magoon.

Thursday, September 15

Morning Session

President Warren J. Scott in the chair.

A progress report of the Committee on Pensions and Protection of Water Works Employees was read by Wm. W. Brush, Chairman, accepted and ordered placed on file.

The remainder of the morning session was devoted to a symposium on "Miscellaneous Uses of Water." Mr. W. D. Collins, Chemist, United States Geological Survey, Washington, D. C., acted as chairman and opened the symposium by a talk on "Industrial Uses of Water." Papers were read as follows:

"The Treatment of Water for Industrial and Boiler Feed Uses," by Sheppard T. Powell, Consulting Chemical Engineer, Baltimore.

"Water Quality Requirements for New England Industries," by Hervey J. Skinner, President, Skinner & Sherman, Inc., Boston. The discussion was participated in by Edward W. Moore, Attmore E. Griffin, E. Sherman Chase, F. J. Lammers, Stuart E. Coburn, Linn H. Enslow, Robert Spurr Weston, and A. W. Benoit.

"Use of Cooling Water in Air Conditioning," by Walton H. Sears, Mechanical Engineer, Metropolitan District Water Supply Commission, Boston, Mass. [read by E. Sherman Chase].

"Modern Motor Pumpers and their Influence on Water Works," by George W. Booth, Chief Engineer, Committee on Fire Protection and Engineering Standards, National Board of Fire Underwriters, New York, N. Y.

These papers were discussed by Linn H. Enslow, Percy A. Shaw, and D. W. Hartford.

Afternoon Session

A paper "Operation of New Filter Plant at Biddeford, Maine," was read by Edwin T. McDowell, Superintendent, Biddeford & Saco

Water Company, Biddeford, Me. This paper was discussed by Harold C. Chandler and Robert H. Erley.

A paper "Double Check Valve Maintenance and Tests in Connecticut," was read by Frederick O. A. Almquist, Senior Sanitary Engineer, State Department of Health, Hartford, Conn.

A paper "Experiences with Check Valve Tests in New Bedford, Massachusetts," was read by Stephen H. Taylor, Superintendent, Water Department, New Bedford, Mass.

These two papers were discussed by William W. Brush, Henry E. Halpin, Charles L. Pool, Francis H. Kingsbury, Arthur V. Harrington, Alfred O. Doane, James J. Dillon, and Arthur C. King.

The Committee on the Advisability of Water Departments Regulating Water Piping and Fixtures within Buildings, through its Chairman, Stephen H. Taylor, presented the following resolution, as amended after discussion:

"*Be It Resolved* in the interest of protection of the health and safety of water consumers and the safety of workmen engaged in water works maintenance:

1. That This Association place itself on record as being opposed to the existence of any form of unprotected cross-connection between pipes carrying water for drinking or personal and domestic use and pipes carrying water of questionable quality or carrying sewage or other liquid of a quality or substance unfit for human consumption.

2. That This Association urge that power be delegated to the proper authority in each municipality, whose duty it shall be to make and enforce proper rules governing the installation of pipes and fixtures within buildings, examine plans and specifications for new installations and to inspect the completed work in place, having authority to approve or reject any device, fixture, pipe size or material, connection, valve or accessory as may be necessary in order to provide proper protection against pollution by cross-connections or back-siphonage and to aid in securing the proper size of pipe to furnish an adequate supply of water to fixtures.

3. That This Association recognize that proper safety appliances should be provided to protect hot water heating systems and to reduce the possibilities of damage to meters on many existing installations.

4. That This Association recommend, pending further information on the subject of deterioration of water quality or of danger to occupants of buildings because of electric grounding on water pipes, that section 909f of the National Electrical Code be followed with reference to grounding of light and power circuits within a building on the street side of the meter and that a permanent metallic circuit be provided around any meter and its connections, both of which precautions will greatly reduce possible effect of electrical currents in so far as they may cause deterioration of water pipes or produce dangerous shocks.

5. That This Association request the coöperation of all manufacturers, architects and designers in preventing the manufacture or installation of improper plumbing, hospital equipment, and improperly protected hot water tank equipment and devices by eliminating the production of the same through the preparation of such specifications as will eliminate faulty equipment and improper connections.

6. That This Association continue to coöperate with the American Water Works Association, the American Public Health Association and others in an endeavor to reduce the hazards of cross-connections in any form."

This resolution was carried and the Committee discharged.

Stephen H. Taylor, as Chairman, reported for the representatives of the Association appointed to coöperate with the American Water Works Association, the National Association of Master Plumbers, and the American Public Health Association in a joint committee to study the sanitary hazards of interior piping fixtures and water storage within buildings. This progress report was accepted and ordered placed on file.

A paper "Historical Development of Cast-Iron Pipe," was read by William R. Conard, Engineer and Consultant, Burlington, N. J.

A motion picture "Pipe and Public Welfare," was shown by Mr. D. W. Johnson, Assistant Engineer, The Cast Iron Pipe Research Association, Chicago. The picture dealt with the historical, technical, and marketing phases of cast-iron pipe.

FRIDAY, SEPTEMBER 16

Morning Session

President Warren J. Scott presiding.

REPORT OF TELLERS OF ELECTION

Number of ballots cast	211
Number of ballots counted	211
For President, George A. Sampson	209
For Vice-President, Leland G. Carlton	204
For Director, Horace L. Clark	207
For Treasurer, Abel Reynolds	204
Blanks	1

(Signed) HENRY T. GIDLEY
C. P. MOAT
HAROLD L. BRIGHAM, *Chairman*

HARRY U. FULLER moved the adoption of the following resolution:

That the thanks of the New England Water Works Association is hereby extended to the Water Works Manufacturers' Association, to the Ladies Committee, and to all others who, by their cordial assistance and coöperation, have made this Convention so successful and enjoyable.

[This resolution was duly seconded and unanimously carried.]

PRESIDENTIAL ADDRESS

By Warren J. Scott, Retiring President

It has been a real privilege to serve as President of the New England Water Works Association. The past year has been, I think, a successful one in the quality of the technical programs, in the returns from the Water Works School, and in the attendance at meetings. Two or three attendance records have been broken. The statistics show that despite some sad and irreparable losses due to death or resignation, they have been more than made up as to number by new members. The Association continues to grow and its financial position is an enviable one.

The previous president pointed to the desirability of extending the activities of the Association so that members in all sections might derive additional benefit from the Association Activities. To my mind this is sound advice and I hope the out-of-Boston meetings will grow in number and value to match the excellent Boston meetings.

The splendid history of this Association has been built around a loyal body of members, a distinguished group of water works superintendents and engineers and their contributions through papers and discussions, and the work of a number of outstanding committees. I think it was our editor who pointed out at one of our meetings that committee activities are the life blood of the Association. This point cannot be over-emphasized.

In some associations there has been created a committee on research and standards which is engaged in the establishment of new committees, coördination of committee activities and review of committee reports. Of course, we have our executive committee but this committee is somewhat burdened with the details of administration so that they do not have the time for unhurried review of committee work. This year a committee on emergency procedures has been established which has an important task and which I am sure will do a creditable job. Other important committees have been continued and all of the inactive ones have been dropped. I strongly urge that the Association consider setting up a Committee on Research and Water Works Practice to report at least each year on the field of committee activities in the Association.

There are two somewhat disturbing factors in the work of water superintendents. One is the inadequacy of the salaries frequently paid for this important job and the second is the lack of tenure of office provisions in many places which would do away with the awarding of the superintendency as a political prize. Presumably the methods of counteracting these tendencies are organization and education. We have here an organization—and a strong one. Education will have to be carried out through an organized plan of public education. This does not mean publicity of the ballyhoo type but an intelligent program through the medium of newspapers and other suitable outlets to acquaint the public with the topics discussed at our meetings and the importance of the water superintendent's job. The Association has recently made a modest start by appointing a committee to publicize this 1938 annual convention. It is hoped that the work can be continued during the year with sufficient appropriation for the purpose. The committee on protection of water works employees might well work along with the publicity committee to further the interests of the water works profession.

Referring back to the subject of committee work, I wish to take this opportunity to thank the Technical Program Committee and particularly its chairman, Karl Kennison, for the excellent job they have done this year. This committee is, of course, a key committee in our organization. To the secretary, to his capable assistant, to the executive committee and to the many members and associates who have given freely of their time and valued assistance on committee activities and on arrangement of meetings, I feel we all owe appreciation.

On motion of Edward W. Moore, it was voted to direct the incoming President to appoint the Committee on Research and Water Works Practice.

On motion of Wm. W. Brush it was voted to discharge the Committee on Pensions and Protection of Water Works Employees.

The President then introduced the President-Elect George A. Sampson.

MR. SAMPSON. I accept the honor which has been bestowed upon me with deep gratitude but with a good deal of misgiving. I am fortunate, and also the Association is very fortunate, in having the guidance of the former presidents, of the executive committee, the secretary, treasurer, editor, and the Water Works Manufacturers' Association, as well as the various committees, and I feel that with this backlog, and the help of all of the members, the New England Water Works Association will still show progress. Again I thank you.

SUPERINTENDENT'S SESSION

Edward F. Morgan, Jr., Superintendent of Public Works, Hudson, Mass., presiding.

A paper, "Automatic Diesel Pumping Stations," was read by Roger G. Oakman, Superintendent, Water Department, Needham, Mass. The discussion was participated in by Percy A. Shaw, Donald C. Calderwood, Harold L. Brigham, Frank L. Flood, P. D. Bowler, William Dawson, William W. Brush, Hugh McLean, Roger W. Esty, and Theodore Cate.

A paper, "The Growing Interest in Pipe Lining," prepared by W. H. Thornhill, Vice-President, Wailes Dove-Hermiston Corporation, New York, was read by G. E. Boyd of that company. Donald C. Calderwood and Roger W. Esty took part in the discussion.

A paper, "Watershed Sanitation," was read by Donald C. Calderwood, Engineer, Pennichuck Water Company, Nashua, N. H. Horace J. Cook, Hugh McLean, Warren J. Scott, Theodore Cate, Harold L. Brigham, Theodore L. Bristol, Robert H. Erley, J. F. McVey, and Linn H. Enslow took part in the discussion.

A paper, "Removal of Iron and Hardness from Water," was read by Daniel J. Saunders, Manager of Industrial Sales, Permutit Company, New York. The discussion was participated in by Horace L. Clark, Roger W. Esty, and Harold L. Brigham.

CHEMISTS' SESSION

Edward W. Moore, Assistant Professor of Sanitary Chemistry, Harvard Graduate School of Engineering, Cambridge, Mass., presiding.

The meeting took the form of a symposium on manufacture, specification and handling of water works chemicals.

A paper on "Lime," was read by J. G. Thompson, Chief Chemist, Lawrence Portland Cement Company, Thomaston, Me. Stuart E. Coburn and Gordon M. Fair took part in the discussion.

A paper on "Copper Sulphate," was read by E. Fitzpatrick, Chief Chemist, Nichols Copper Company, Laurel Hill, N. Y. Attmore E. Griffin and Gordon M. Fair took part in the discussion.

A paper on "Alum, Ferrisul, Sodium Aluminate," was read by F. A. Abbiati, Assistant Sales Manager, Merrimac Division, Monsanto Chemical Company, Boston, Mass. Stuart E. Coburn, Gordon M. Fair, and Everett M. Battey took part in the discussion.

A paper on "Activated Carbon," was read by E. A. Sigworth, Technical Sales Division, Industrial Chemical Sales Division, West

Virginia Pulp and Paper Company, New York. Everett M. Battey, Stuart E. Coburn, and W. A. Helbig took part in the discussion.

A motion picture showing the laying of a main near Birmingham, Alabama, was shown by Mr. G. E. Boyd, of the Wailes Dove-Hermiston Corporation.

Motion pictures, taken by Mr. George F. Merrill during the Fifty-Sixth Annual Convention at Poland Springs, Me., in September, 1937, were shown.

President Sampson. This concludes the program of the Fifty-seventh Annual Convention. A good time has been had by all, the registration has been 689, and that is the largest for any convention, with but one exception. The meeting is adjourned.

ANNUAL REPORT OF THE SECRETARY

Mr. President and Gentlemen of the New England Water Works Association:—The Secretary submits herewith the following report of the changes in membership during the past fiscal year, and the general condition of the Association.

The present membership is 798, constituted as follows: 12 Honorary Members, 657 Members, 107 Associate Members, and 22 Corporate Members. The detailed changes are as follows:

MEMBERSHIP

September 1, 1937.	Honorary Members, Total..........		12		
	Withdrawals	0	0	12	
	Elected	0		0	12
September 1, 1937.	Members, Total		650		
	Withdrawals:				
	Resigned	8			
	Died	12			
	Dropped by Executive Committee .	5	25	625	
	Elected:				
	September, 1937	10			
	November, 1937	3			
	December, 1937	3			
	January, 1938	2			
	February, 1938	5			
	March, 1938	5			
	April, 1938	2			
	June, 1938	2		32	657
September 1, 1937.	Juniors, Total		0		
	Elected:				
	September, 1937	1	1	1	
	Withdrawals:				
	Dropped by Executive Committee .	1		1	0
September 1, 1937.	Associates, Total		99		
	Withdrawals:				
	Resigned	2			
	Dropped by Executive Committee .	1	3	96	
	Elected:				
	September, 1937	6			

	December, 1937	1			
	January, 1938	1			
	February, 1938	1			
	March, 1938	1		10	
	Reinstated:				
	November, 1937	1		1	107
September 1, 1937.	Corporates, Total		22		
	Withdrawals	0	0	22	
	Elected	0		0	22
September 1, 1938.	Total Membership				798
September 1, 1937.	Total Membership				783
	Net Gain				15

ELECTIONS.

Members.

September 21, 1937.	John A. Andrew, Arthur Boniface, J. Arthur Carr, Harry A. Faber, Charles W. Harris, Leigh I. Holdredge, James P. Joyce, Harry J. Krum, Francis J. McCarty and Wilfred J. Michel. (10)
November 18, 1937.	Francis Edward Blaney, James Joseph Kehoe and Thomas Francis Monahan. (3)
December 16, 1937.	Robinson D. Buck, Allan T. Gifford and Clarence H. Reed. (3)
January 20, 1938.	Charles Albert Root and Harold B. Scales. (2)
February 17, 1938.	Clarence S. Ball, Forrest D. Bradshaw, Frederick W. Peet, Truman H. Safford and Roscoe H. Suttie. (5)
March 17, 1938.	Everett O. Boothby, William Foulds Covil, Ralph P. Hall, Laban Clough Morrill and Leander G. Smith. (5)
April 14, 1938.	Albert E. Casey and Roland F. Kittredge. (2)
June 23, 1938.	A. H. Bruhn and Thomas E. Hegarty. (2)

Juniors.

September 21, 1937.	John T. Bergeson. (1)

Associates.

September 21, 1937.	Activated Alum Corporation, The Barrett Company, Carson-Cadillac Corporation, The Farnan Brass Works Company, Fields Point Manufacturing Corporation and "Proportioneers, Inc." (6)
December 16, 1937.	National Gunite Contracting Company. (1)
January 20, 1938.	Brown Company. (1)
February 17, 1938.	Devonshire Artic Chemical Company. (1)
March 17, 1938.	Ralph P. Hall Company. (1)

Reinstatements

Associates.

November 18, 1937. Cohoes Rolling Mill Company. (1)

Withdrawals

Members.

Resigned: Christopher F. Bingham, Julius W. Bugbee, Arthur T. Clark, Harold S. Crocker, Harry R. Leach, Albeus P. Murray, Raymond V. McNamara and Dana M. Pratt. (8)

Died: Charles R. Bettes, R. A. Cairns, Thomas J. Carmody, Byron I. Cook, Earl C. Craig, Lewis M. Hastings, David A. Heffernan, Roland F. Kay, Horace Kingman, James A. McMurry, Morton R. Milne and Leonard C. Robinson. (12)

Dropped by Executive Committee: Daniel A. Cashman, George K. Clement, Harold J. Lockwood, Daniel C. Smith and John O. Tabor, Jr. (5)

Juniors.

Dropped by Executive Committee: John T. Bergeson. (1)

Associates.

Resigned: Republic Steel Corporation and Vellumoid Company. (2)

Dropped by Executive Committee: Union Water Meter Company. (1)

Receipts for the Fiscal Year, September 1, 1937 to September 1, 1938.

Entrance Fees			$ 163.00
Annual Dues:			
Members	$3,080.75		
Corporates	200.00		
Associates	1,940.00	$5,220.75	
Fractional Dues:			
Members	$ 67.50		
Associates	50.00	117.50	
Past Dues:			
Members	$ 203.00		
Associates	80.00	283.00	
1938-1939 Dues:			
Members	$ 36.00	$36.00	
Total Dues			$5,657.25
Dividends and Interests			423.70
Advertisements			3,035.65
Subscriptions			511.74
Journals			156.81
Reprints			389.98
Sundries			49.41
Total Receipts			$10,387.54

There is due the Association:

Entrance Fees	$ 9.00	
Dues	887.50	
Advertisements	378.00	
Journals	2.50	
Reprints	3.00	
Subscriptions	4.00	1,284.00
Total		$11,671.54

Respectfully submitted,
(Signed) **Frank J. Gifford**, *Secretary.*

ANNUAL REPORT OF THE TREASURER

President and Members of the New England Water Works Association

I herwith submit the annual report of the Treasurer of the New England Water Works Association for the year ended August 31, 1938:

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS
GENERAL FUND

For the Year ended August 31, 1938

Receipts			
Initiation Fees		$ 163.00	
Dues		5,657.25	
Interest		423.70	
From Publication of JOURNAL			
Advertisements	$3,035.65		
Subscriptions	511.74		
Sale of JOURNAL	156.81		
Sale of Reprints	389.98		
Sale of Halftones, Electros, etc.	24.66	4,118.84	
Miscellaneous			
Membership Certificates	15.00		
Receipts for Outing	5.00		
Sundry	4.75	24.75	
Total Receipts			10,387.54
Disbursements			
Publication of JOURNAL			
Printing	2,809.66		
Plates	520.79		
Reporting	345.54		
Reprints	282.94		
Stationery and Postage	144.51		
Editor's Salary	500.00		
Sundry	54.61	4,658.05	
Office and General			
Certificate of Membership	60.65		
Secretary's Salary (2 Years)	800.00		
Assistant Secretary's Salary	1,404.33		
Secretary's Expense	64.05		
Treasurer's Salary (2 Years)	200.00		
Treasurer's Bond	5.00		
Printing, Postage and Stationery	265.47		
Office Rent	1,200.00		
Electricity	39.86		
Telephone and Telegraph	155.42		

Audit	65.00		
Sundry	265.57	4,525.35	
			9,183.40
Total Receipts, brought forward			$10,387.54
Disbursements, brought forward		$ 9,183.40	
Meetings and Committees			
Badges	$ 30.31		
Water Works School	125.00		
Printing, Postage and Stationery	534.25		
Stereopticon	108.84		
Convention Expense	170.15		
Miscellaneous Expense	53.63	1,022.18	
Total Disbursements			10,205.58
Excess of Receipts over Disbursements			181.96
Balance, General Cash, August 31, 1937			645.22
Balance, General Cash, August 31, 1938			
Represented by, Cash in First National Bank of Boston		777.18	
Cash in Office		50.00	
			$ 827.18

STATEMENT OF ASSETS AND FUNDS
As at August 31, 1938
Assets

Cash in Banks, Invested Funds		
City Five Cents Savings Bank, Haverhill, Massachusetts	$ 2,000.00	
Farmers and Mechanics Savings Bank, Framingham, Massachusetts	2,068.46	
Franklin Savings Bank, Boston, Massachusetts	2,000.00	
Haverhill Savings Bank, Haverhill, Massachusetts	2,000.00	
Home Savings Bank, Boston, Massachusetts	311.25	
Mechanics Savings Bank, Reading, Massachusetts	2,000.00	
Pentucket Savings Bank, Haverhill, Massachusetts	2,000.00	
The People's Savings Bank, Worcester, Massachusetts	2,000.00	
Suffolk Savings Bank, Boston, Massachusetts	2,000.00	
Total Invested Cash		$16,379.71
General Fund		
Cash, First National Bank of Boston	777.18	
In Office	50.00	
	827.18	
Furniture and Fixtures	1,180.00	2,007.18
Total Assets		$18,386.89

Funds

Invested Funds		$16,379.71
General Fund		
Balance, August 31, 1937	1,825.22	
Add Excess of Receipts over Disbursements	181.96	
Balance, August 31, 1938		2,007.18
Total Funds		$18,386.89

Note:

The above statement is prepared on a cash basis
and does not reflect the following:

Accounts Receivable, Dues	$ 887.50
Due on Account of Advertising and other Miscellaneous Charges	396.50
	$1,284.00
Dues and Subscriptions Paid In Advance	41.00

No depreciation has been taken on Furniture and Fixtures.

Respectfully submitted,

Leland G. Carlton, *Treasurer.*

Springfield, Mass., September 9, 1938

Leland G. Carlton, *Treasurer*,
New England Water Works Association,
Springfield, Massachusetts.

Dear Sir:

In accordance with your request, we have made an examination of the accounts and financial records of the New England Water Works Association for the year ended August 31, 1938.

We submit herewith the following attached statements:

Exhibit A Statement of Assets and Funds as at August 31, 1938
Exhibit B Statement of Cash Receipts and Disbursements, General Fund, for the Year ended August 31, 1938

We traced all recorded receipts into the depository bank, verified the general fund bank account and petty cash fund as at August 31, 1938, and examined properly approved vouchers for all disbursements.

We also verified by direct confirmation the invested funds on deposit in savings banks.

Respectfully submitted,

Scovell, Wellington & Company

ANNUAL REPORT OF THE EDITOR.

To the New England Water Works Association: The Editor submits herewith the following report for the year ending August 31, 1938.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received or disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1937, and March and June, 1938, issues of the JOURNAL is included in the Report of the Treasurer.

Table 1 is a statement of the material published.

Table 2 gives a comparison of the JOURNAL for the past year with preceding years.

Size. The four issues contained 699 pages, of which 510 were text.

Cost. The gross cost of the JOURNAL was $4,658.05, equivalent to $5.93 per member; the net cost was $539.21, equivalent to $0.69 per member.

Reprints. Reprints of each paper have been furnished to the author at cost.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	798
Subscribers	129
Exchanges	16
Total	943

(JOURNALS have been sent to all subscribers.)

Respectfully submitted,
GORDON M. FAIR, *Editor*.

TABLE 1.

STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1937, AND MARCH AND JUNE, 1938, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Date.	Pages of.								
	Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	Total Cuts.
September, 1937	132	0	132	0	40	5	0	177	54
December, 1937	87	33	120	10	38	5	0	173	12
March, 1938	125	5	130	0	38	5	0	173	37
June, 1938	125	3	128	0	38	5	5	176	44
Total	469	41	510	10	154	20	5	699	145

TABLE 2.
COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	FOUR ISSUES FOR FISCAL YEAR ENDING AUG. 31.									
	1929	1930	1931*	1932	1933	1934	1935	1936	1937	1938
Average edition (copies printed) ..	1,200	1,350	1,260	1,200	1,125	1,100	1,100	1,100	1,100	1,100
Average membership	831	822	816	813	805	796	786	770	772	785
Circulation at end of year	993	980	955	957	930	928	918	903	920	943
Pages of text	507	570	410	437	420	499	470	477	435	510
Pages of text per 1,000 members ..	610	693	502	537	522	627	598	619	561	650
Total pages, all kinds	745	812	682	644	594	645	643	642	627	699
Total pages per 1,000 members ..	896	988	836	790	738	811	808	834	812	890
GROSS COST:										
Total	$6,740.87	$8,054.59	$6,135.33	$5,024.03	$4,712.16	$5,411.30	$4,780.75	$5,380,68	$5,040.86	$4,658.05
Per page	9.06	9.92	9.00	7.80	7.93	8.39	7.54	9.16	8.04	6.66
Per member	8.12	9.80	.752	6.18	585	6.80	6.08	7.64	6.53	5.93
Per member per 1,000 pages	9.77	12.07	9.00	9.62	9.85	10.53	9.46	11.89	10.41	8.49
Per member per 1,000 pages text	16.01	17.19	18.34	14.30	13.94	13.62	12.93	16.01	15.01	11.63
NET COST:										
Total	$1,857.58	$3,664.76	$1,252.21	$1,121.20	$1,176.77	$1,916.27	$1,332.99	$1,499.58	$489.13	$539.21
Per page	2.07	4.51	1.84	1.74	1.98	2.97	2.07	2.34	0.78	0.77
Per member	2.24	4.46	1.53	1.38	1.46	2.41	1.70	1.95	0.63	0.69
Per members per 1,000 pages ..	2.50	5.49	2.24	2.14	2.46	3.73	2.64	3.03	1.01	0.98
Per member per 1,000 pages text	4.41	7.82	3.73	3.16	3.48	4.83	3.61	4.08	1.46	1.35

*Including comprehensive index, 1882 to 1930.

REPORT OF FINANCE COMMITTEE.

To the Executive Committee of the New England Water Works Association:

GENTLEMEN: The Finance Committee submits the following:

BUDGET FOR YEAR 1938-39

Estimated Revenue

Initiation Fees	$ 200
Dues	5,500
Interest and Dividends	400
JOURNAL	3,700*
Miscellaneous	100
	$9,900

Expenditures

Office	$4,000
Journal	4,800*
Committee Work	400
Meetings and Misc.	500
Contingencies	200
	$9,900

*As all reprints are sold at actual cost and represent a variable amount over which the association has no control we have eliminated the item of reprints when considering the recommended expenditures and estimated income.

We recommend that a change in the accounting set up be made to take care of the reprint condition.

We also recommend that a committee be appointed to consider revising the entire accounting system of the Association, and it be given power to install a modern double entry system of accounts if after investigation they think it for the best interests of the Association to do so.

We feel that the above budget and recommendations, if accepted, will allow the Association to live within its income, carry on the excellent work of the JOURNAL, maintain and develop the office and quarters, and at the same time provide ample funds for meeting expense and committee work.

As customary an audit of the books has been made by a firm of Certified Public Accountans and their report incorporated in the Treasurer's report.

Respectfully submitted,

PAUL F. HOWARD,
WALTER P. SCHWABE,
D. C. CALDERWOOD, *Chairman*

ANNUAL REPORT OF LEGISLATIVE COMMITTEE.

September 1937—September 1938

Mr. President and Members of the New England Water Works Association:

The Legislative Committee of the Association respectfully presents this report of its activities during the year:

The Committee named was made up of the same members as last year, but owing to a change in his connection with the Rhode Island Department of Public Health Mr. Pool of Providence resigned and his place on the committee was filled by Mr. James J. Dillon. Later upon the death of Mr. Heffernan, Mr. Leon A. Goodale was appointed.

In Massachusetts, about 2600 petitions were presented, and from their titles about 50 were noted as being of possible interest to water works men. Upon examination 5 out of the 50 seemed to deserve attention and were followed throughout their course during the session. Ten hearings were attended by the Committee and letters were sent to the Committee on Judiciary opposing the repeal of the lien law. So far as possible announcements were made at the Association meetings giving the dates of hearings to be held upon these bills.

Because of their importance perhaps five bills should be mentioned here. The lien law was not repealed but was completely rewritten, and became law on June 16, 1938. The more essential changes were (1) the including of charges for services and materials as well as water, (2) extending the term covered from one year to one year and six months previous to the date of filing, and (3) providing for the release of the water lien in case of error without invalidating the tax title.

The hardy perennial requiring the licensing of operators of internal combustion engines, a labor union petition disguised as a safety measure, was again presented and was referred to the next annual session.

Another bill which should be watched for next year would in effect require water works authorities to issue permits for fishing in water supplies to any citizen of the commonwealth. This Association by resolution adopted March 17, put itself on record in opposition.

An opening wedge for such bills was driven in spite of strong opposition by the Metropolitan District Commission, the State Dept. of Public Health, water works men and others by the passage over the Governor's veto of a law allowing fishing in Lake Cochituate, a reserve supply for the Metropolitan District.

The bill extending the jurisdiction of water supply patrolmen regardless of town lines was passed.

In the other New England States no proposed legislation was reported as being of particular importance to water works men.

Respectfully submitted,
(Signed) STEPHEN H. TAYLOR,
LEON A. GOODALE,
JAMES J. DILLON,
N. W. GRISWOLD,
GEO. A. REED,
P. R. SANDERS,
S. S. ANTHONY,
ARTHUR C. KING, *Chairman*.

OBITUARY

Patrick Gear

Past Vice President
New England Water Works Association

Patrick Gear, one of the most highly respected members of the New England Water Works Association, passed away on October 24, 1938, at his home in Holyoke, where for twenty-five years he had been Superintendent of the Water Department.

Born on October 14, 1858 in Ardfert, County Kerry, Ireland, the son of Patrick and Margaret (Greaney) Gear, he came to America in 1874. After working on a farm for a few years, he found employment with the Holyoke Machine Company and became an expert machinist. In November 1897 he entered the Water Department of the City of Holyoke, and, after various promotions, was appointed Superintendent in May 1913, and so continued until the time of his death.

Such is the brief record of a successful life—brief, because of the continuity of faithful, acceptable service in his chosen vocation.

Joining the New England Water Works Association in 1913, Mr. Gear was throughout his remaining life one of its most interested and valuable members. He was a regular attendant at meetings and conventions, served on various committees, and in 1921 was elected a Vice President. His contributions to discussion—compounded of sound sense and humor, and spiced with his inimitable Kerry dialect—were always welcome, and will long be remembered by water works men.

Patrick Gear was a strong man, physically and mentally—a rugged individualist with definite opinions, which he was prepared to defend with quick wit and ready tongue, but always in the best of good will. Self-respecting, capable, and an enthusiast in his work, he was a fine example of the best type of municipal executive. He had great capacity for enduring friendships. Always a hard worker, he found relaxation in golf, which he played for twenty years and consistently scored in the higher nineties.

His family life was fortunate and happy. On November 22, 1887 he was married to Mary Shea, who died on April 28, 1924. Three children survive him: Anna M., a teacher in the Holyoke High School;

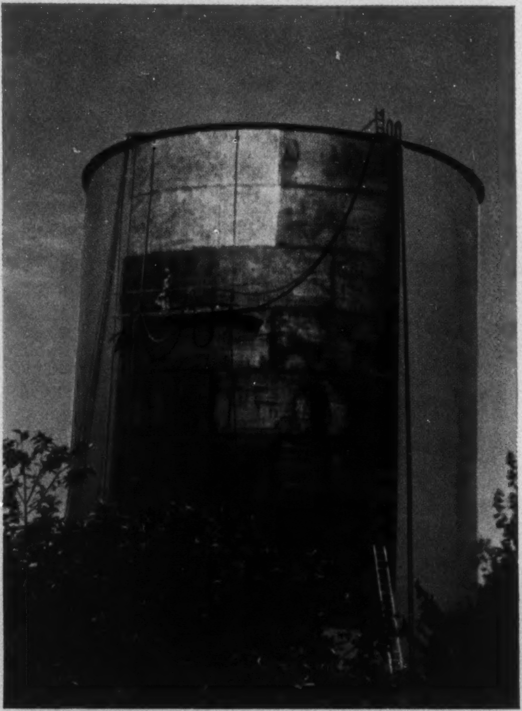
Katherine M., a clerk in the Holyoke Gas & Electric Company, and Patrick E., a physician practicing in Holyoke.

That Mr. Gear had reached a high place in the city which he served is evidenced by the following closing paragraph of an editorial in the October 24, 1938 issue of the Holyoke *Daily Transcript*:

> "The young Irishman who left his native shores and found Holyoke the place to live for more than sixty years and attain a measure of success in life that few attain, had most of the virtues that bring success over the hard way. There was honesty, sobriety, enthusiasm, a tremendous capacity for hard work, an inclination to seek the good points rather than the bad in his fellow men, and crowning them all, faith in God Almighty and His infinite goodness. In his younger days he was one of the strongest men in all Holyoke. In the rough and tumble of the day's work there were few men who cared to stay with him to the end. But with that strength went a courtliness in speech and conduct when the occasion called for it, that is ever the hall-mark of a real gentleman."

There are few members of the Association whose passing will leave a greater void than that left by that colorful Irishman affectionately known to all as Pat Gear.

ALEXANDER H. O'BRIEN
FRANK A. BARBOUR



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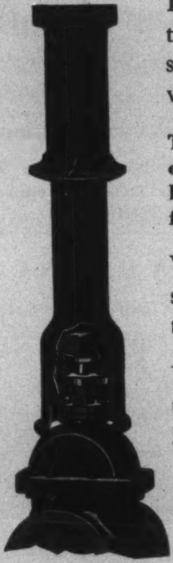

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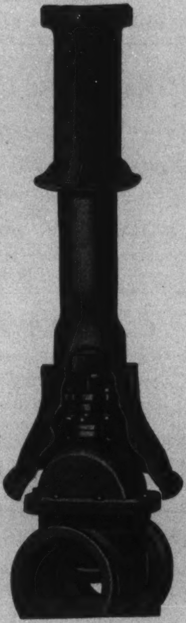

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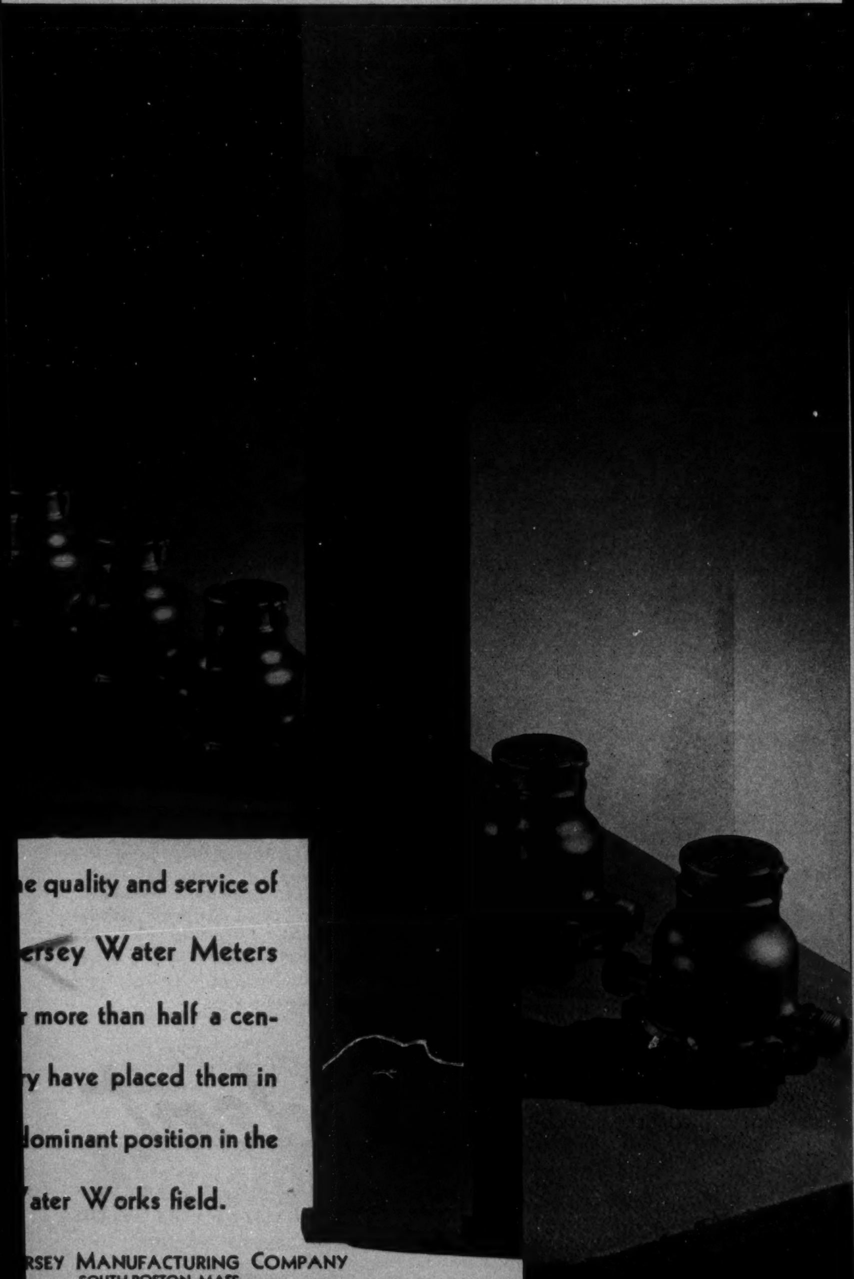

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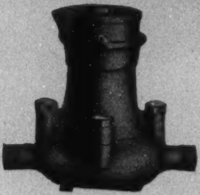

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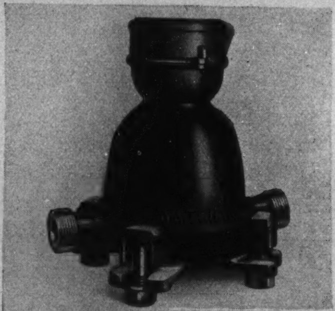

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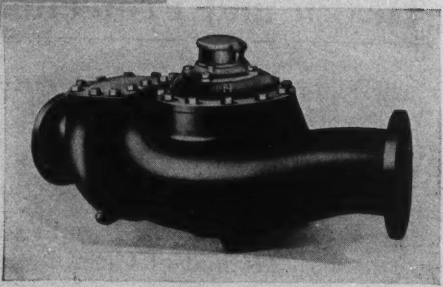

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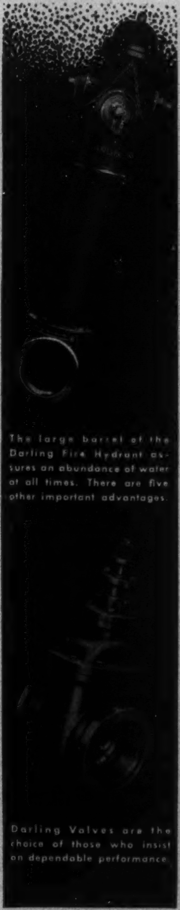

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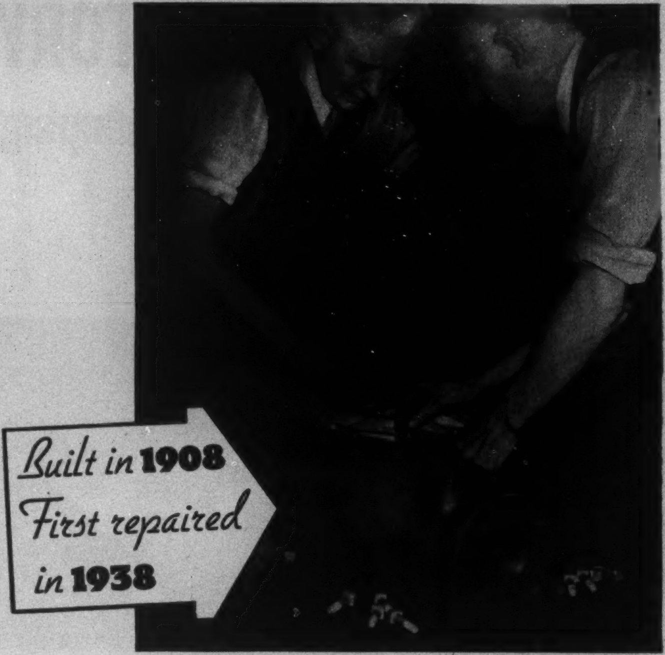

and by the same men who built it!

Left, Frederick Ditchfield. Length of service, 55 years.

Center, Empire Meter Number 653058. Length of service, 30 years. Piston and intermediate replaced. Meter now ready for many years of additional service.

Right, William Giroud. Length of service, 51 years.

NATIONAL *Meters*

NATIONAL METER COMPANY, 4207 First Avenue, Brooklyn, New York
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Complete Service

is offered by our plant — from copy to the bound book. We have the facilities and experience necessary to assist you in preparing your printed matter, your magazine, or book. We know that we can be helpful and practical and the costs of the finished product are always fair.

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The Heffernan Press
150 Fremont Street
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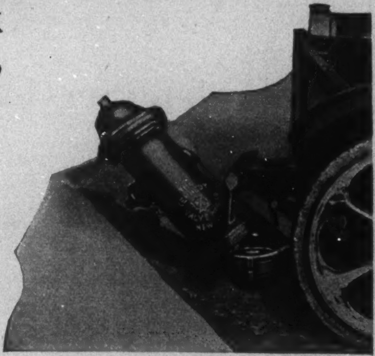
When a truck runs "amuck"

and crashes
into a
Kennedy
SAFETOP
Fire Hydrant



Send for Bulletins

IN NO INSTANCE—either on demonstration test or in accidental collisions, has the Safety Breakable Section ever failed in its function of preventing breakage of the major and expensive parts of the SAFETOP. The only parts that need be replaced after breakage are a threaded standpipe ring and a stem coupling. These parts cost $6.00—a very small fraction of the cost of the complete hydrant which must ordinarily be replaced after breakage from accidental collision. Repairs do not necessitate shutting off the water pressure, and can be completed within half an hour.

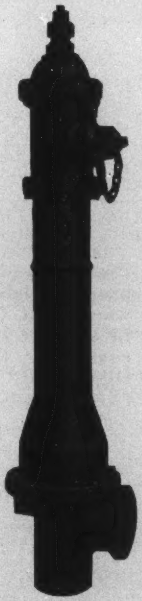
In addition to its unique safety feature, the Kennedy SAFETOP Fire Hydrant assures quick response with full main pressure delivered at the nozzle in fire service; and its simple operating mechanism and wear-resisting valve facings last indefinitely. Write for bulletins describing its many special features.

The Kennedy Valve Mfg. Co., Elmira, N. Y.

KENNEDY
SAFETOP FIRE HYDRANT
REG. U.S. PAT. OFF.

EDDY

Valves and Hydrants



Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

●

Eddy Valve Co.

WATERFORD NEW YORK

LEAD PIPE

Used by leading WATER WORKS for over 50 years. If proper weight is used, combined with good workmanship, your FINAL COST is assured, as REPAIRS are unnecessary. LEAD PIPE IS sufficiently ductile to conform to any sagging condition. There is no RUSTING of pipe or joints; no DISCOLORATION of water.

HIGHEST QUALITY SOFT OMAHA PIG LEAD

LEAD WOOL

Every atom pure lead

For calking pipe joints under the most difficult conditions.

RED LEAD

For rust-proofing tanks and pipes.

Write for Water Works specifications.

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SOLDER

National-Boston Lead Co.

800 Albany Street Boston, Mass.

LUDLOW HYDRANTS

always work!

Special design protects Ludlow Hydrants from subzero temperatures. Water drains from the bottom—cannot freeze in the barrel. This means a big saving, eliminating need for digging and replacing. These hydrants save on water, the valves being perfectly seated to prevent leakage and undue wear.

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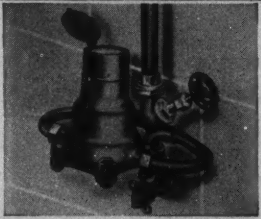
FOR MINIMUM TROUBLE
AND EXPENSE

The SMITH PROTECTOP Safety Coupling Standpipe is designed to permit repairs incident to collision to be made in less than fifteen minutes at a minimum cost.

After collision, the only parts necessary to replace are the standpipe clamp and the hydrant stem frangible coupling.

The hydrant valve, being of the compression type and guided throughout its travel, will remain closed. Even if it is open at the time of collision it will close instantly thus preventing flooding of streets.

SMITH
WATER WORKS
SPECIALTIES & SUPPLIES
THE A.P.SMITH MFG.CO. *East Orange, N.J.*



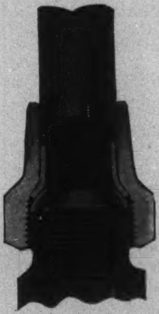
Correct Basement
METER SETTING

Shown here is a meter setting with a Ford Angle Valve and a Ford Valve COPPERHORN. The compression valve in the COPPERHORN is convenient for shutting off back water or for customer use in repairing faucets. Let us tell you more about modern meter settings.

The Ford Meter Box Co.
WABASH, INDIANA

HAYS begins at the MAIN

Since 1869 Hays has built to the exacting requirements of the Water Works Industry. Tap the Main with a Hays Tapping Machine and follow through with dependable Hays Service Fittings for iron pipe, lead or copper. Hays Corporation Stops and Curb Stops are made in all styles and sizes. Write for Catalog.

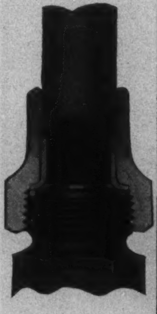


HAYS RADIUS SEAL JOINT

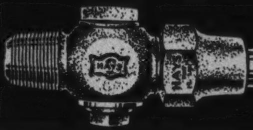
This type of joint was designed to meet the specific requirements of certain Water Departments and is available directly on all styles of Hays Copper Service fittings.

HAYS DOUBLE SEAL JOINT

This joint features a 2-faced pipe flare (45° + 90°) and a 2-faced machined seal (45° + 90°) which is by test the strongest flanged connection available. Available by Adapter on any Corporation Stop and directly on more than 400 styles and sizes of Hays Service and Plumbing fittings.



USE THE HAYS COPPER SERVICE METHOD



Hays Adapts Copper to meet any Requirements

As a pioneer in the development of copper pipe services, Hays has popularized its use by making it easily adaptable to meet existing line equipment economically. Every community can have the advantage that copper pipe makes possible from Main to Curb to House with the Hays Copper Service Method. Let us have your problem.

HAYS MFG. CO.

ERIE, PA.

HAYS

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BATH FIXTURES
COPPER PLUMBING
GAS SERVICE GOODS
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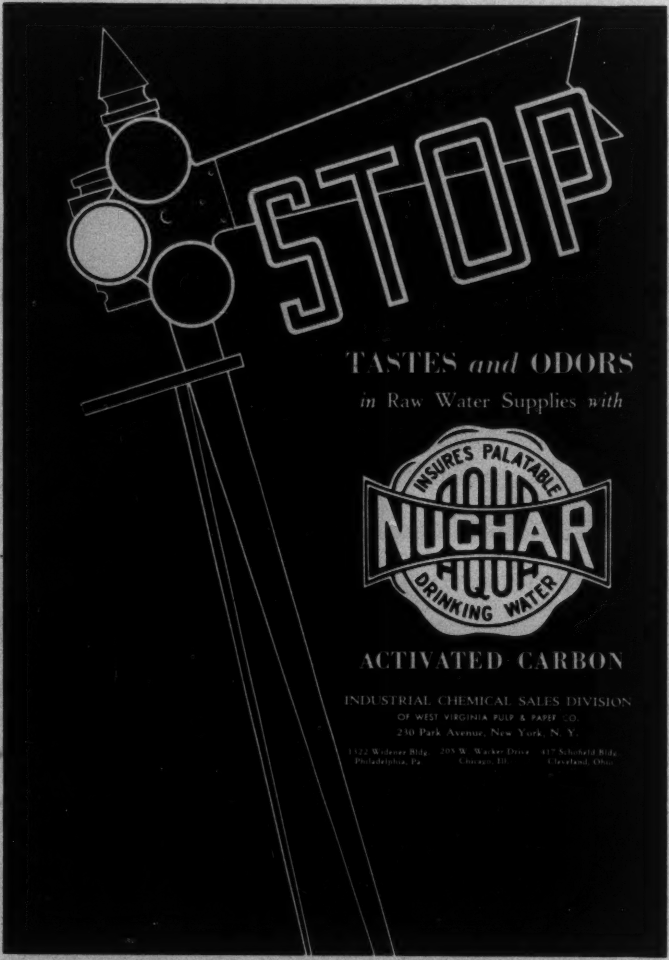
TAPPING MACHINES



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in Raw Water Supplies *with*

INSURES PALATABLE
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DRINKING WATER

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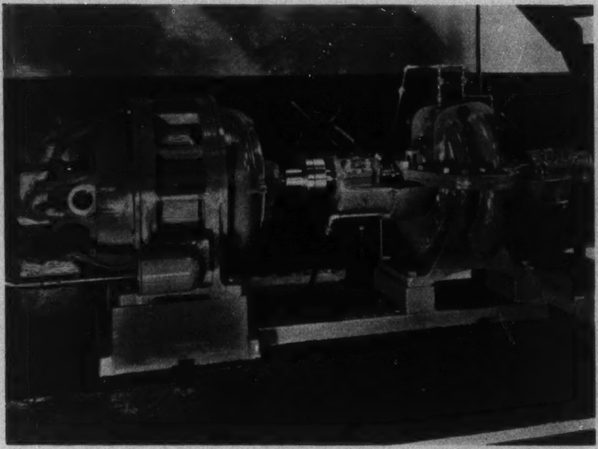
DE LAVAL

Pumps in East Providence, R. I. Water Department

All pumps in this Water Works Station are now De Laval



The latest addition to this plant is the two-stage centrifugal pumping unit shown in the above photograph.

The capacity of the new pump is 800 gallons per minute against a total head of 336 feet.

This pump was recently installed to replace an existing unit of another manufacture which was removed and the pumping station is now 100% De Laval equipped.

This station has an enviable record of high sustained efficiency with De Laval pumps over a period of years.

Complete contract by

TURBINE EQUIPMENT COMPANY
OF NEW ENGLAND
80 Federal Street Phone LIBerty 5993-5994 Boston, Mass.

New England Representative for

DE LAVAL STEAM TURBINE COMPANY
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REAL VALUE FOR YOUR CHLORINATION DOLLAR

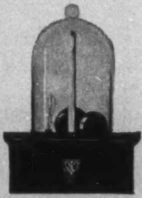
DEPENDABLE CHLORINATION
at seventy miles an hour...

SEVENTY miles an hour—one hundred and three feet per second—is the average water velocity through the injector throat of a W&T Chlorinator. To find a material which would withstand the erosive action of this constant high velocity, W&T engineers searched the market, made exhaustive tests, tried out every available material. Finally, they found it—a material equally resistant to the erosive action of the water and to the corrosive action of chlorine solution, a material which would last for years and yet one which could be machined with the high degree of accuracy required.

Expensive—yes—this constant research, this high standard of the best material money can buy, this rigid supervision over every detail of design and manufacture. But the result is a great Chlorinator—an equipment we are proud to sell and you will be proud to own, an equipment designed and built to fulfill every requirement for the accurate, dependable control of chlorination.

The very nature of the task Chlorination has to do warrants the best equipment. When the choice is up to you, be sure you specify W&T—your reward will be constant dependability, micrometric accuracy and negligible maintenance expense.

Ask for Technical Publications
describing W&T Chlorinators.



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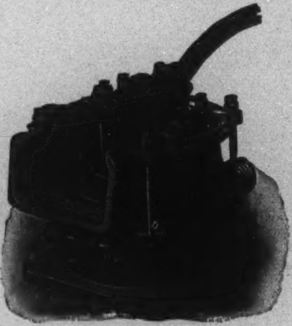
EDSON
PUMPS and ACCESSORIES



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Few Products In Any Field Are So Clearly Recognized for Superiority of Service As

SPUN BITUMASTIC LINING

REG. U. S. PAT. OFF.

The Report of the Committee on PIPE LINE COEFFICIENTS of the New England Water Works Association definitely proves the absolute economic necessity of lining all water pipe.

BITUMASTIC SPUN LINING is assigned a higher value of the coefficient *C* than any other lining. This insures the highest initial flow. More important —this high flow will be maintained for many years.

BITUMASTIC ENAMEL is not affected by tuberculating waters. Actual inspection of pipe in service and carrying tuberculating waters shows BITUMASTIC unaffected. This is real proof.

No taste, color, or odor imparted to the water.

Write for further information.

Wailes Dove-Hermiston Corporation

17 Battery Place, New York, N. Y.

The "COREY" Hydrant

Why you should use GENUINE COREY HYDRANTS

Water to Nozzles quicker than other Hydrants.

Standpipe can be removed and replaced without shutting off water in main.

Ease of operation insured by knuckle joint principle.

Only 13 turns to completely open or completely close, but full flow with only 4 turns.

Nozzles screwed in — not leaded.

Can be lengthened without shutting off water.

Will not flood if broken.

Positive Drip — cannot freeze.

Standpipe can be revolved quarter turns — Nozzles always in right direction.

Ask for our Catalog "G"

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New England Sales Manager, Lock Box 2, Northboro, Mass.

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X. Henry Goodnough, Inc.
Engineers

● The town of Needham can well be proud of its new water pumping station, for as city officials state, "Our water troubles will be over for a good many years to come." Believed to be the first Municipal Diesel driven Turbine Pump installation in New England, this system is equipped with a Fairbanks-Morse single-cylinder Diesel which powers an F-M Turbine Pump to economically supply the best quality water from an underground reservoir.

Needham, as well as many other New England municipalities equipped by Fairbanks-Morse, is showing a substantial saving in operating costs. Get the facts on F-M power and pumping equipment by writing to Fairbanks, Morse & Co., 178 Atlantic Avenue, Boston, Mass.

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Power - Pumping - and - Weighing - Equipment

Water Works Officials

Cultivate the goodwill of your customers

Use the

METER-MASTER

To settle high bill complaints

The METER-MASTER is the only portable rate recorder that gives a continuous record for 6 and 24 hour periods, or 24 and 72 hour periods, from either a single or a compound meter.

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The QUALITY-PLUS LINE of Brass Goods

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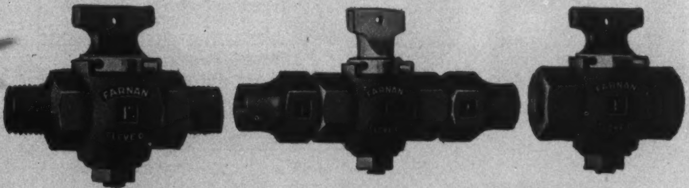
All accurately machined, ground, assembled and tested to Farnan Brass Standards—which mean—the highest quality and durability obtainable at any price!



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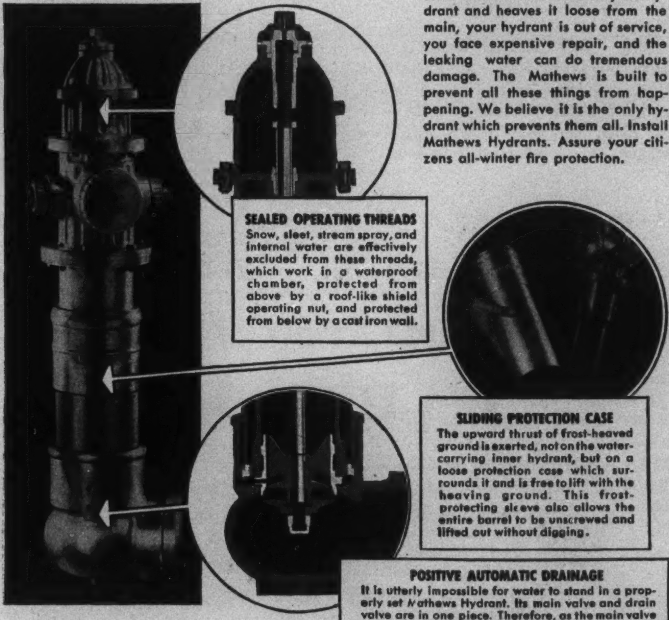
FARNAN BRASS WORKS CO.
Established 1852
CLEVELAND OHIO

Before trouble starts, we ask you to

Install WINTERPROOF Mathews Hydrants!

When winter really comes, water will freeze. If it freezes on your hydrants' operating threads or in their stand pipes, those hydrants can't be operated. If it freezes around your hydrant and heaves it loose from the main, your hydrant is out of service, you face expensive repair, and the leaking water can do tremendous damage. The Mathews is built to prevent all these things from happening. We believe it is the only hydrant which prevents them all. Install Mathews Hydrants. Assure your citizens all-winter fire protection.



SEALED OPERATING THREADS
Snow, sleet, stream spray, and internal water are effectively excluded from these threads, which work in a waterproof chamber, protected from above by a roof-like shield operating nut, and protected from below by a cast iron wall.

SLIDING PROTECTION CASE
The upward thrust of frost-heaved ground is exerted, not on the water-carrying inner hydrant, but on a loose protection case which surrounds it and is free to lift with the heaving ground. This frost-protecting sleeve also allows the entire barrel to be unscrewed and lifted out without digging.

POSITIVE AUTOMATIC DRAINAGE
It is utterly impossible for water to stand in a properly set Mathews Hydrant. Its main valve and drain valve are in one piece. Therefore, as the main valve opens, the leather faced drain-valve must slide down across the drain-orifice effectively closing it. As the main valve closes, the drain valve must open.

MATHEWS HYDRANTS

***Made by* R. D. WOOD COMPANY**

Manufacturers of Sand Spun Pipe (centrifugally cast in sand molds) and R. D. Wood heavy-duty gate valves for water works

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Meter Box
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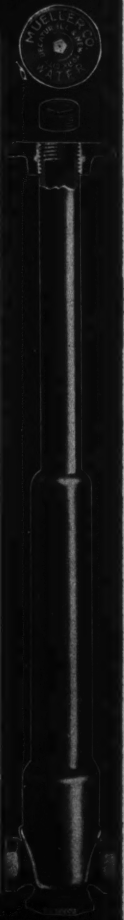

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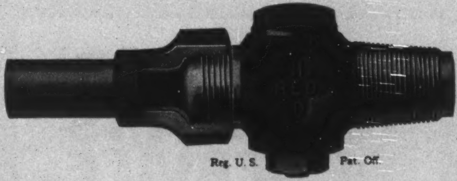

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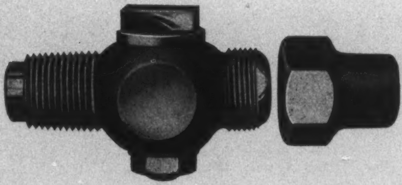

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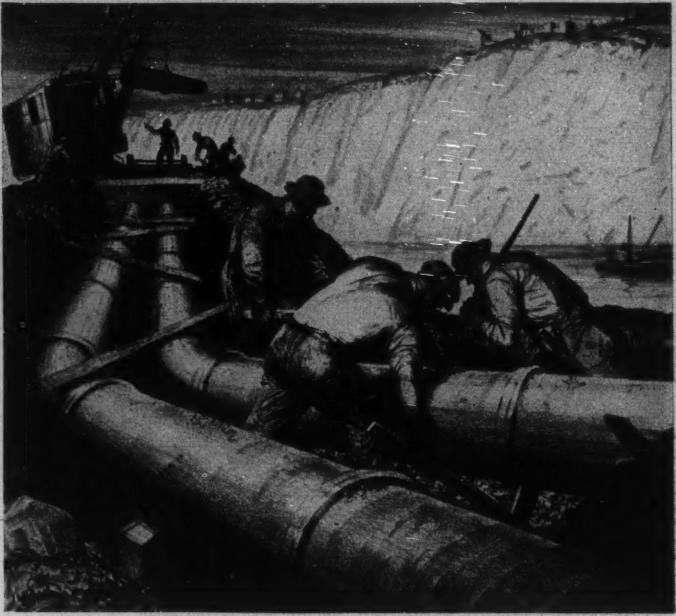

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